

United States
Department of
Agriculture

Forest Service

Northeastern
Forest
Experiment
Station

Research Attainment Report

Fiscal Year 1987

Abstract

This report contains information on research attainment during fiscal year 1987 at the Northeastern Forest Experiment Station of the USDA Forest Service. Data presented include the funding and staffing for each problem, a narrative summary of the attainment in each problem, and a bibliography of all publications resulting from this research.

KEYWORDS: Research, attainment, research management

Research Attainment Report

Fiscal Year 1987

United States Department of Agriculture
Forest Service
Northeastern Forest Experiment Station

Preface

This attainment report serves as one basis on which to evaluate USDA Forest Service research programs and work unit performance. It also provides information required by the Congress, the Department of Agriculture, and the Office of Management and Budget for their use in evaluating Forest Service research progress. This report for the Northeastern Forest Experiment Station will be aggregated with reports from other Forest Experiment stations to prepare a national report on research programs and accomplishments

The basis for this report is the Research Work Unit Description (RWUD) for each work unit. The RWUD defines each unit's mission and problems to be studied to accomplish that mission. The approach to detailed investigation of each problem is described in a problem analysis. The problem analysis serves as a basis for preparing a series of study plans, each contributing to the problem solution, and ultimately, to accomplishment of the work unit mission.

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Introduction

The Research Work Unit Attainment Reports in Part I each begin with a Research Work Unit Summary. This summary is in the form of a table, listing the problem number and title, the functional account funding the problem, the current level of funding, the current staffing (scientist years) and a tally of the number of publications produced, whether in the work unit, through extramural research, or through cooperative research.

The Research Work Unit Summary is followed by further information for each problem giving the attainments for a single problem. These reports give bibliographic information on each publication resulting from the research on a particular problem, plus a narrative summary of the attainment for that problem.

Part II is a bibliography of all the publications produced as a result of research conducted by the Northeastern Forest Experiment Station in Fiscal Year 1987, listed in alphabetical order by author under the proper functional account.

**Part I: Research Work Unit
Attainment Reports**

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4101

GROWTH AND CULTURE OF CENTRAL APPALACHIAN HARDWOODS
SMITH, H. CLAY, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. ECONOMIC INFORMATION COMPARING SILVICULTURAL ALTERNATIVES AND PLAN COST EFFECTIVE STRATEGIES	TMR	98	1.2			1
2. ECOLOGICALLY PROVEN AND ENVIRONMENTALLY ACCEPTABLE ALTERNATIVES TO CLEARCUTTING	TMR	310	1.7	3		2
3. GUIDELINES TO BETTER ADDRESS CURRENT SILVICULTURAL AND FOREST MANAGEMENT CHALLENGES	TMR	82	1.1	1		

Problem 1

**ECONOMIC INFORMATION COMPARING SILVICULTURAL
ALTERNATIVES AND PLAN COST EFFECTIVE STRATEGIES
FY 87 Research Attainments**

Publications

Cooperative

Brock, Samuel M.; Jones, Kenneth D.; Miller, Gary W. 1986. Felling and skidding costs associated with thinning a commercial Appalachian hardwood stand in northern West Virginia. Northern Journal of Applied Forestry. 3 (4): 159-163.

Attainment

Research from this problem area demonstrates the benefits and financial advantages of doing timber management practices in central Appalachian hardwood stands. In general, about 70 percent of the private forest landowners in the region have never managed their timber resource. More active management practices will result in improvements in future stand quality and value, thus more revenue. Logging costs and harvest revenues were determined for three types of commercial thinnings in 50-year-old Appalachian hardwood stands. A commercial contractor logged the area using chain saws and rubber-tired skidders. Time-study data were used to compute production rates for felling marked trees and skidding tree-length logs. Cost to log merchantable decked logs ranged from 10.79 to 11.99 dollars per unit. Regression equations were developed for predicting felling and skidding times for each thinning treatment. Data from these equations can be used to estimate production rates and costs for similar thinning operations. This research indicates that even for a small tract of timber there is an opportunity for the landowners to do commercial thinnings, thereby leaving their stands in a more productive condition for future revenues.

Economic information is being requested by national forest systems—Regions 8 and 9. Also universities, colleges, industrial, and state organizations are using the available economic information in this problem area for teaching and application purposes. Fernow appraisal information was provided to a local lumber company and West Virginia University Division of Forestry on a how-to-use-it basis.

Problem 2**ECOLOGICALLY PROVEN AND ENVIRONMENTALLY
ACCEPTABLE ALTERNATIVES TO CLEARCUTTING
FY 87 Research Attainments**

Publications**Research Unit**

Lamson, Neil I. 1987. Estimating northern red oak site-index class from total height and diameter of dominant and codominant trees in central Appalachian hardwood stands. Research Paper NE-605. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3.

Wendel, G. W.; Lamson, Neil I. 1987. Effects of herbicide release on the growth of 8- to 10-year-old hardwood crop trees. Research Paper NE-598. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5.

Wendel, G. W.; Smith, H. Clay. 1986. Effects of a prescribed fire in a central Appalachian oak-hickory stand. Research Paper NE-594. Broomall, PA: United States Department of Agriculture, Northeastern Forest Experiment Station. 8.

Cooperative

Kochenderfer, J. N.; Helvey, J. D.; Wendel, G. W. 1987. Sediment yield as a function of land use in central Appalachian Forests. In: Central Hardwood Forest Conference VI; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 497-502.

Shallenberger, Scott W.; Carvell, Kenneth L.; Smith, H. Clay. 1986. Crown/stem diameter relationship of four Appalachian hardwoods. West Virginia Forestry Notes. September; 12: 4-6.

Attainment

Both wood products and tourism are important industries in the Appalachians. Alternatives to clearcutting are needed to allow foresters to manage timber resources for wood production in sensitive areas. Prescribed burning is often suggested as a potentially useful tool for regenerating specific hardwood species such as oaks. Five years after a burn in West Virginia many of the overstory trees died or lost vigor and were susceptible to insect and disease problems. A major loss of tree value was observed in butt log quality. Fire cannot be recommended as a useful regeneration tool in the Appalachian hardwood stands until further research is completed. Five years after a 20 percent aqueous solution of glyphosate was used to release crop trees in young immature hardwood stands, diameter growth increase significantly for the released trees. Glyphosate was effective in controlling most hardwood species and the crop trees responded to release. Site productivity is extremely important when applying management and silvicultural practices to Appalachian hardwood stands. Regression equations for predicting total height as a function of dbh are available for five hardwood species. Also a relation of dbh to tree crown diameter was developed for four Appalachian hardwood species. There is a potential to record stem diameters using crown width measurements from aerial photographs. If basal area volume type computations are reasonable, a considerable savings in field data collection is possible. Total sediment yield was measured up to 6 years for three forested areas with different land use and logging histories. Data implications are that past land use can have a long-term effect on sediment yields and stream turbidity on formerly farmed or logged areas.

Problem 3**GUIDELINES TO BETTER ADDRESS CURRENT SILVICULTURAL
AND FOREST MANAGEMENT CHALLENGES
FY 87 Research Attainments**

Publications**Research Unit**

Lamson, Neil I.; Smith, H. Clay. 1987. Precommercial treatments of 15- to 40-year-old northern hardwood stands. In: Managing Northern Hardwoods; 1986 June 23-25; Syracuse, NY. Syracuse, NY: SUNY, College of Environmental Science and Forestry: 160-176.

Attainment

Research outputs are oriented toward providing guidelines and recommendations for managing forest stands for the production of high quality timber products and non-timber resources. Great diversity in stand conditions and landowner objectives require ongoing development of silvicultural guidelines to meet specific forest management goals. Guidelines result in more widespread application of acceptable harvesting and cultural practices. Guidelines for economical practices give forest owners greater incentives to manage their timber resources. Guidelines for cultural and harvesting practices were provided to foresters and landowners through workshop presentations and proceedings that will be published during FY88. Staff members provided guidelines for managing precommercial northern hardwood stands at a workshop held at Syracuse, NY. How to select and release crop trees including future stand response was discussed. Approximately 250 foresters and landowners attended the workshop. Cost consideration guidelines for managing hardwood stands using partial cuttings were presented at Penn State University workshop. More than 200 landowners and foresters were provided with guidelines based on experience and current available information. This information will help forest managers apply harvesting and cultural practices while landowners will have a better understanding of their options. Crop tree release guidelines were presented to national forest personnel in a training session and to Region 8 and 9 silviculturists as part of a continuing education program. Videos were another research output used for developing guidelines by project staff. In cooperation with NE-4301 and West Virginia University, a second video, building forest roads, in a three-video series was completed during FY87.

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4102

ECOLOGY AND MANAGEMENT OF BEECH-BIRCH-MAPLE TYPES IN THE
NORTHEAST
TUBBS, CARL, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. A REFINED AND EXPANDED LAND CLASSIFICATION SYSTEM IS NEEDED	TMR	156	1.6	3		
2. NEED TO IMPROVE SILVICULTURAL PRESCRIPTIONS FOR NORTHERN HARDWOODS AND MIXED WOOD STANDS	TMR	128	1.3	2		1
3. BETTER PROCEDURES ARE NEEDED FOR IMPROVING THE QUALITY OF NORTHERN HARDWOODS	TMR	104	1.1	5		
4. TIMBER AND WILDLIFE HABITAT INTEGRATION	TMR	98	1.0	3	1	
M5. A LACK OF MASS PRODUCTION TECHNIQUES PREVENTS LARGE-SCALE PLANTING OF PITCHLOBLLOLY PINE HYB.	TMR	93	1.0	1	1	

Problem 1 **A REFINED AND EXPANDED LAND CLASSIFICATION SYSTEM IS NEEDED**
FY 87 Research Attainments

Publications

- Research Unit Leak, William B. 1987. Characteristics of five climax stands in New Hampshire. Res. Note NE-336. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.
- Leak, William B. 1987. Fifty years of compositional change in deciduous and coniferous forest types in New Hampshire. Canadian Journal of Forest Research. 17 (5): 388-393.
- Ubi, Martina William. 1987. Extractable micronutrient cations, exchangeable cations and cation exchange capacity of acid forest soils. Normal, AL: Alabama Agricultural and Mechanical University. M.S. thesis.

Attainment

Long-term records (52-53 years) from 30 1/4 acre cruise plots on the Bartlett Experimental Forest, NH, showed that species composition is moving toward a predominance of 1-2 tolerant species determined by soil condition (habitat). Beech and sugar maple are becoming predominant on fine tills, and beech on sandy tills. Red spruce and/or hemlock are increasing rapidly on soils characterized by shallow bedrock, hardpan, or outwash; hemlock is more aggressive than spruce at elevation below 500-550 m. A second study defined the basal areas, diameter distribution, and species mixes typical of climax hardwood and softwood stands growing on specific soils. The results define the direction and end points of the successional process in New Hampshire, and provide a basis for estimating the time required to reach the climax condition. Apparently, there are multiple climax forests in the region, as determined by soil/climatic conditions, that develop within a period of 250-300 years following heavy cutting. The results emphasize the need to base silvicultural decisions and techniques on soils information. Soil/site information, partly based on the results of this work, is used on the White Mountain National Forest for silvicultural planning. General soil/site guidelines are incorporated in a revised silvicultural guide for northern hardwoods in the Northeast, and are being disseminated by a recent series of workshops in Maine, Vermont, and New Hampshire.

Problem 2**NEED TO IMPROVE SILVICULTURAL PRESCRIPTIONS FOR
NORTHERN HARDWOODS AND MIXED WOOD STANDS
FY 87 Research Attainments**

Publications**Research Unit**

Leak, William B.; Solomon, Dale S.; DeBald, Paul S. 1987. Silvicultural guide for northern hardwood types in the Northeast (revised). Res. Pap. NE-603. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36 p.

Voorhis, Nancy G. 1987. Thinning guides for developing desirable sugarbush trees. Maple Syrup Digest. 27 (1): 27-30.

Cooperative

Scott, Charles T.; Voorhis, Nancy G. 1987. Northeastern forestry survey site index equations and site productivity classes. Northern Journal of Applied Forestry. 3: 144-148.

Attainment

A revised silviculture guide was prepared for northern hardwood and mixed wood stands that provides the latest information on cutting methods, regeneration, stocking levels, yields, and site relationships. Nitrogen applications increased growth of all species in a young aspen-birch-red maple stand, while lime and phosphorus increased growth of bigtooth aspen and birch. Nitrogen increased growth of bigtooth aspen and birch. Nitrogen increased mortality, while lime reduced it. Direct-seeded white pine exhibited better-quality stems and less severe damage than adjacent planted pine due to the spacing within rows. Effects of tree thinning intensities in a young sugar maple stand on diameter, crown, and height growth were used to develop a guide for growing desirable sugarbush trees, without excessive crowding or open spaces in the canopy. A generalized site index equation was developed for common tree species in the Northeast; then by referring to available yield tables, the equation was used to estimate the limits in site index by species that define four productivity classes; 20-50, 50-85, 85-120, and 120+ Ft³/acre/year (culmination of mean annual increment). This array of findings provide managers in the Northeast with a broader solution of techniques for culturing and fertilizing hardwood stands, artificially regenerating white pine, developing sugarbushes, and producing site capability. In addition to publications of the results, much of the current practical information has been disseminated by workshops, training sessions, and field demonstrations in New England to both public and private foresters.

Problem 3**BETTER PROCEDURES ARE NEEDED FOR IMPROVING THE
QUALITY OF NORTHERN HARDWOODS
FY 87 Research Attainments**

Publications**Research Unit**

Garrett, Peter W.; Funk, David T. 1986. Limiting injury in sugar maple to tapping. *Maple Syrup Digest*. 26: 32-34.

Lewis, Ann M. Test of the air - seeding hypothesis using sphagnum hyaline cells. Paper presented at AIBS meeting, August 12, 1986.

Lewis, Ann M. 1987. Two mechanisms for the initiation of embolism in tracheary elements and other dead cells. In: American Society of Plant Physiologists Annual Meeting; 1987 July 23; St. Louis, MO. Petersham, MA: [Publisher name unknown]:

Lewis, Ann M. 1987. Two mechanisms for the initiation of embolism in tracheary elements and other dead plant cells under water stress. International Botanical Congress; 1987 July 24 - August 1.

Lewis, Ann Marie. 1987. Two mechanisms for the initiation of embolism in tracheary elements and other dead plant cells under water stress. Cambridge, MA: Harvard Forest. 136 p. Ph.D. dissertation.

Attainment

The regional supply of northern hardwoods capable of providing high grade saw logs with veneer is too low to support industries utilizing high grade raw material. American beech is one of the most difficult trees to grow properly. A recently completed study suggests that poor quality beech results partly from external influences such as suppression and damage to crown. Crown damage most commonly results from glaze, frost and logging. Internal physiological factors controlling the size, pattern and distribution of branches can be taken advantage of by utilizing silvicultural techniques which allow the upper portion of the crown to grow freely but which will crowd the lower portion of the crown. This should accentuate the natural processes which limit branch diameter growth and accelerate branch mortality without reducing stem diameter growth unduly. Experiments with Sphagnum and Thuja provided support for the "air-seeding" hypothesis: the phenomenon of air-bubble entry into tracheids that disrupts the water columns. The theory could relate to height, growth and quality responses of trees under stress.

Dissection of open pollinated sugar maple that were wounded to simulate a maple sap taphole indicated that trees vary in their ability to compartmentalize or wall-off injury.

Problem 4

**TIMBER AND WILDLIFE HABITAT INTEGRATION
FY 87 Research Attainments**

Publications

Research Unit

Tubbs, Carl H. 1986. Silvicultural technique for improving wildlife tree habitat in northern hardwood forests. In: The northern hardwood resource: management and potential; 1986 August 18-20; Houghton, MI. Barrington, NH: Michigan Tech University: 244-249.

Tubbs, Carl H.; DeGraaf, Richard; Yamasaki, Mariko; Healy, William M. 1987. Guide to wildlife tree management in New England northern hardwoods. Gen. Tech. Rep. NE-118. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 30 p.

Yamasaki, Mariko; Tubbs, Carl H. 1986. Wildlife tree management in New England northern hardwood forest. In: Joint conference of the New England Society of American Foresters, Maine Chapter of the Wildlife Society, and the Atlantic International Chapter of the American Fisheries; 1986 April 1; Portland, ME. Portland, ME: Maine Agricultural Experiment Station Misc. Pub.: 109-134.

Extramural

Miller, Donald; Gradischer, Lee; Orzel, Joseph; Leak, William B.; Miller, Ellen. 1987. Changes in vegetation and breeding bird use in an Atlantic White Cedar swamp from 1951 to 1984. In: Laderman, Aimlee D., ed. Atlantic White Cedar Wetlands Symposium; October 9-11; Woods Hole, MA. Woods Hole, MA: Marine Biological Laboratory: 229-230.

Attainment

Wildlife is often an important goal of small private landowners and wildlife habitat must be provided on public land managed for timber. Often timber production goals and wildlife habitat goals appear to conflict requiring that techniques and management systems be devised to reduce or avoid impacts on one or the other. Experimental evidence for use as a basis in devising ways of integrating the two uses is very sparse. Analysis of existing studies and the literature resulted in interim guides that show ways to evaluate the impact of the timber production on wildlife and vice versa and offers suggestions of how to use existing silvicultural techniques to achieve wildlife habitat goals.

Results of this work were included in a major Forest Service Region 9 conference, also attended by representatives from the New England state organizations.

Problem M5

**A LACK OF MASS PRODUCTION TECHNIQUES PREVENTS
LARGE-SCALE PLANTING OF PITCHLOBLOLLY PINE HYB.
FY 87 Research Attainments**

Publications

Research Unit

Garrett, Peter. 1987. Introducing innovation in forest genetics. In: Introducing research results into practice: proceedings of a bilateral Bulgarian and American Seminar; 1986 October 6-17; Sofia, Bulgaria. Sofia, Bulgaria: Bulgaria Academy of Sciences Publishing House: 165-170.

Extramural

Pellett, Norman E.; Alpert, Karen. 1986. Rooting softwood cuttings of mature *Betula papyrifera*. International Plant Propagators Soc. Proc. 35: 519-525.

Attainment

A study of the effects of cutting date, IBA concentrations and tree-to-tree variation indicated that current-year cuttings of white birch rooted best when dipped for 5-seconds in a 4000 or 6000 ppm solution of IBA. Mid-stem cuttings were best for early-season tests; apical cuttings were best later in the season. Rooting success varied among trees from 8 percent to 49 percent. The results provide a method for successfully producing clonal material, although growth and survival of the rooted cuttings require further study before major applications take place.

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4103

THE ROLE OF ENVIRONMENTAL STRESS ON TREE GROWTH AND
DEVELOPMENT

GREGORY, ROBERT A., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. PHYSIOLOGICAL EFFECTS OF SITE ACIDIFICATION ON TREE GROWTH AND DEVELOPMENT.	TMR	451	2.4	2		
2. ANATOMICAL AND PHYSIOLOGICAL EFFECTS OF STRESS AND ITS POSSIBLE ROLE IN PREDISPOSING TREES.	TMR	389	1.5	3		
51. MISCELLANEOUS	TMR	4	.1	1		

Problem 1**PHYSIOLOGICAL EFFECTS OF SITE ACIDIFICATION ON TREE GROWTH AND DEVELOPMENT.
FY 87 Research Attainments**

Publications**Research Unit**

Wong, B.L.; Melhuish, J.H.; McQuattie, C.J. 1987. Response of mycorrhizal and non-mycorrhizal loblolly pine seedlings to different pH and Pb concentrations. In: Symposium 7th North American Conference on Mycorrhizae; 1987 May 3-8; Gainesville, FL. Abstract. 75 p.

Wong, B.L.; Melhuish, J.H.; McQuattie, C.J. 1987. The effect and distribution of Al in mycorrhizal and non-mycorrhizal loblolly pine seedlings. In: Abstracts of the Annual Meetings of the Mycological Society of America, Carleton Univ.; 1987 June 22-25; Ottawa, Canada. Ottawa, Canada: Annual Meetings of the Mycological Society of America: 107 p.

Attainment

As atmospheric deposition and soil acidity increase, many heavy (or trace) metals become increasingly available in soils which may affect the growth and physiological functions of mycorrhizal fungi and those of the associated plant. This study was initiated to evaluate and characterize the role of the loblolly pine mycorrhizal association in trace metal uptake, metal accumulation within the plant and fungus, and the resultant affects on seedling growth when exposed to a variety of metals at different concentrations and pH levels. The results of this study show that morphological and anatomical alterations of the roots in response to metal and pH treatments occurred prior to any evidence of effect to the above-ground portions of the seedlings. The quantity of treatment metal within the plant components is dependent upon the metal, the concentration of the exposure metal, and the acidity of the treatment solution. The results indicate that the Al taken up by the seedling is not retained in the roots but is readily transported to the shoot, and the mycorrhizal condition of the roots does not enhance or restrict this transport. Analysis of the roots treated with Pb show that 88 to 97 percent of the Pb remains within the roots, while less than 13 percent of the Pb taken up by the seedling is transported to the shoot.

Problem 2

**ANATOMICAL AND PHYSIOLOGICAL EFFECTS OF STRESS AND
ITS POSSIBLE ROLE IN PREDISPOSING TREES.
FY 87 Research Attainments**

Publications

Research Unit

Gregory, R.A.; Williams, M.W.; Wong, B.L.; Hawley, G.J. 1986. Proposed scenario for dieback and decline of *Acer Saccharum* in northeastern U.S.A. and southeastern Canada. IAWA Bul. 7: 357-369.

Tabor, C.A.; Barnett, N.M. 1987. An experimental system for studying the relationships between the embryo and megagametophyte of *Pinus strobus* during seed germination. Can. J. Bot. 65: 1212-1 217.

Wong, B.L.; Melhuish, J.H.; McQuattie, C.J. 1987. The effect and distribution of A1 in mycorrhizal and non-mycorrhizal loblolly pine seedlings. In: Abstracts of the Annual Meetings of the Mycological Society of America; 1987 June 22-25; Ottawa, Canada. Abstract. Ottawa, Canada: Annual Meetings of the Mycological Society of America: 107 p.

Attainment

A deficiency in the amount of cuticular wax on the surface of red spruce may predispose high elevation stands to winter injury and thus contribute to the decline of this species. Results from a range-wide study showed that the amount of surface wax on red spruce leaves was related to transpiration rate and winter injury; leaves with thinner cuticles transpired more and had greater winter injury. Natural insect defoliation of sugar maple is also thought to be a contributing factor in the reported decline of this species. Defoliation studies have clearly shown that defoliated sugar maple trees have lower fall starch reserves, are less hardy, and exhibit more overwinter dieback and mortality. These studies are providing baseline information for further research on the effects of atmospheric pollutants on winter injury of these species.

Problem 51

MISCELLANEOUS
FY 87 Research Attainments

Publications

Research Unit

Tabor, C.A.; N.M. Barnett. 1987. An experimental system for studying the relationships between the embryo and megagametophyte of *Pinus strobus* during seed germination. *Can. J. Bot.* 65:1212-1217.

Attainment

Within the seed of eastern white pine, the mature diploid embryo is surrounded by a mass of maternal tissue, the haploid megagametophyte. This close physical association between the two organisms renders them ideal experimental material for studying interrelationships during germination and early seedling development. This may involve the transfer of chemical substances from one organism to the other. An experimental system was devised that provided a reliable means for conducting quantitative studies on these interrelationships. By controlling imbibition rates, germination was synchronized and cultures had uniform morphological characteristics. Early seedling development was affected by time of removal of the megagametophytes from the embryos. Nitrate reductase activity was detected in embryos and shoots of intact megagametophytes, but declined as the seedlings aged. Activity within roots increased as seedlings matured and may be localized in the root tip. Nitrite was produced within the megagametophyte; however, enzyme activity was dependent upon sustained, direct access to the inducing substrate, nitrate, in the culture medium. When megagametophytes remained intact for the initial 8 days of germination, seedlings developed epicotyls, and nitrate reductase activity within the roots was significantly greater than in 6-day cultures. In essence, by 8 days these seedlings appeared to have passed a threshold and were autotrophic. These findings support the hypothesis that the megagametophyte exerts a controlling influence on development of a mature embryo into a seedling during germination. The data may serve as a basis for subsequent studies on the role of possible regulators of nitrate reductase.

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4151

CULTURE OF NORTHEASTERN SPRUCE-FIR FORESTS
BLUM, BARTON M., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. THE NEED TO REFINE SILVICULTURAL PRESCRIPTIONS	TMR	127	1.6	2		1
2. ENEMIES OF SPRUCE BUDWORM NOT EVALUATED IN CONTEXT OF SILVICULTURAL PRESCRIPTIONS.	TMR	146	2.1	6		2
3. CANNOT ACCURATELY PREDICT GROWTH AND YIELD RESPONSES.	TMR	128	1.1	6		2
4. SOIL FERTILITY, SITE PRODUCTIVITY AND THE NUTRIENT REQUIREMENTS OF MAJOR SPECIES	TMR	18	1.2			1

Problem 1

THE NEED TO REFINE SILVICULTURAL PRESCRIPTIONS
FY 87 Research Attainments

Publications

Research Unit

Frank, Robert M. 1986. Shelterwood—an ideal silvicultural strategy for regenerating spruce-fir stands. In: Integrated Pest Management Symposium for Northern Forests; 1986 March 24-27; Madison, WI. Madison, WI: Cooperative Extension Service, University of Wisconsin - Extension: 139-150.

Northeastern Forest Exp. Stn. 1987. Forest research Orono, Maine. NE-INF-74-87. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Cooperative

Crawford, Hewlette S.; Frank, Robert M. 1987. Wildlife habitat responses to silvicultural practices in spruce-fir forests. In: Transactions of the 52nd North American Wildlife and Natural Resource Conference; 1987 March 23-25; Quebec City. Washington: The Wildlife Management Institute: 98-107.

Attainment

A study of the variation of the bud-flushing phenology of white spruce has been completed and a manuscript prepared. Variation in bud flushing data as related to degree-day accumulation was determined among seed sources, families and individual white spruce [*Picea glauca* (Moench) Voss] trees on both a provenance study plantation and a progeny test of select trees on the Penobscot Experimental Forest in north-central Maine. The primary purpose was to determine the feasibility of improving resistance to spruce budworm defoliation by selection for late bud flushing. Comparisons with native red spruce indicate that while some improvement in late flushing may be possible, it is unlikely that late flushing dates comparable to the mean for native red spruce can be achieved for white spruce.

An analysis of the development of regeneration following the final harvest of a shelterwood in a spruce-fir stand is nearing completion.

Projected shortages of eastern spruces and balsam fir may be minimized if a substantial acreage of young trees is intensively managed to increase growth rates of individual trees. Ten-year results from a spacing study on the Penobscot Experimental Forest indicate significant gains in periodic diameter and height increments when compared to unthinned controls. Maximum diameter gains due to spacing in balsam fir was 205 percent; red spruce 116 percent; and white spruce 190 percent. Maximum increases in height growth were 81 percent for balsam fir; 30 percent for red spruce; and 46 percent for white spruce. Sawtimber crops can be expected in about 60 years.

Problem 2

**ENEMIES OF SPRUCE BUDWORM NOT EVALUATED IN CONTEXT
OF SILVICULTURAL PRESCRIPTIONS.
FY 87 Research Attainments**

Publications

Research Unit

Grimble, David G. 1987. Canusa publications useful to northeastern forest-land managers. Northern Journal Applied Forestry. 4: 105-109.

Jennings, Daniel T.; Collins, Judith A. 1987. Coniferous-habitat associations of spiders (Araneae) on red spruce foliage. Journal of Arachnology. 14 (3): 315-326.

Jennings, Daniel T.; Collins, Judith A. 1987. Spiders on red spruce foliage in northern Maine. Journal of Arachnology. 14 (3): 303-314.

Jennings, Daniel T.; Houseweart, Mark W.; Dunn, Gary A. 1986. Carabid beetles (Coleoptera: Carabidae) associated with strip clearcut and dense spruce-fir forests of Maine. The Coleopterists Bulletin. 40 (3): 251-263.

Jennings, Daniel T.; Parker, Frank D. 1987. Habitats and spider prey of *Dipogon sayi sayi* (Hymenoptera: Pompilidae) in Washington County, Maine. The Great Lakes Entomologist. 20 (3): 135-140.

Jennings, Daniel T.; Pase, Herbert Allen, III. 1986. Spiders preying on *Dendroctonus frontalis* (Coleoptera: Scolytidae). Entomological News. 97 (5): 227-229.

Cooperative

Collins, Judith A.; Jennings, Daniel T. 1987. Nesting height preferences of eumenid wasps (Hymenoptera: Eumenidae) that prey on spruce budworm (Lepidoptera: Tortricidae). Annals Entomological Society of America. 80: 435-438.

Collins, Judith A.; Jennings, Daniel T. 1987. Spruce budworm and other lepidopterous prey of eumenid wasps (Hymenoptera: Eumenidae) in spruce-fir forests of Maine. Great Lakes Entomologist. 20 (3): 127-133.

Attainment

Investigations were focused on 1) the effects of silvicultural treatments on natural enemies of the spruce budworm, and 2) habitat requirements of important predators of the spruce budworm.

Studies in northern Maine showed that species diversity of carabid beetles was greater in strip-clearcut stands (uncut residual plus clearcut strips) than in dense stands. Carabid beetle activity was greatest during the early and late larval stages of the spruce budworm. Neither age of strip clearcut (1-6 yr) nor litter depth had much influence on mean catches and mean number of species/trap/week.

Eumenid wasps that prey on late instars of the spruce budworm showed no significant difference in acceptance of trap-nesting blocks hung at four heights (0.0, 0.5, 1.0, and 1.5 m); however, there was a trend toward increased acceptance at 0.5 m. Spruce budworm larvae accounted for 94 percent of the wasps' provisioned prey.

Densities of spiders on red spruce foliage varied significantly between two budworm sampling periods. Differences in densities were attributed to 1) seasonal activities and reproductive cycles of individual species, 2) weather during foliage collection, and 3) sampling methods. The spider fauna on red spruce was closely allied with that of other northern conifers.

We found no evidence of nest-site competition between spider and eumenid wasps that prey on spruce budworm.

Problem 3**CANNOT ACCURATELY PREDICT GROWTH AND YIELD RESPONSES.****FY 87 Research Attainments**

Publications**Research Unit**

Solomon, Dale S.; Hosmer, Richard A. 1987. SIMSAP and SIMTIM: Modeling growth in even-aged northern hardwoods from saplings to sawtimber. *The Compiler*. 5 (2): 20, 22-23.

Solomon, Dale S.; Hosmer, Richard A.; Hayslett, H.T., Jr. 1987. FIBER handbook: A stand model for spruce-fir and northern hardwood types. Res. Pap. NE-602. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 p.

Solomon, Dale S.; Hosmer, Richard A.; Hayslett, Homer T., Jr. 1987. FIBER 2.0: Modelling growth in spruce-fir, northern hardwood, or mixed spruce-fir and northern hardwood stands. *The Compiler*. 5 (2): 21, 24-25.

Solomon, Dale S. 1986. Mortality in the spruce-fir forest. In: Gertner, ed. *Midwest forest economists and midwest forest mensurationists*; 1986 August 13-14; Zion, IL. Urbana, IL: Department Forestry, University of Illinois: 17. Abstract.

Solomon, Dale S.; Hosmer, R.A. 1986. Predicting stand growth using FIBER. In: Morz and Reed, eds. *A conference on the northern hardwood resource: management and potential*; 1986 August 18-20; Houghton, MI. Houghton, MI: Michigan Technological University: 36. Abstract.

Solomon, Dale S.; Hosmer, Richard A. 1987. FIBER - A computerized forest stand growth model. American Pulpwood Association Technical Release 87-R-43.

Cooperative

Brann, Thomas B.; Reams, Gregory A.; Solomon, Dale S. 1987. Spruce budworm growth impact study: 1983 report. Maine Agric. Exp. Stn. Rep. Misc. Rep. 319. Orono, ME: Maine Agricultural Experiment Station. 53 p.

Leak, William B.; Solomon, D.S.; DeBald, P.S. 1987. A revised silvicultural guide for northern hardwood types in the northeast. Res. Pap. NE-603. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36 p.

Attainment

FIBER, a two stage matrix model has been expanded to include all species within the region encompassing the spruce-fir and northern hardwood types. The model is being modified and will be used a basis of comparison for spatial and temporal differences in forest growth. The data base used for construction and testing of the model is being used by the National Acid Precipitation Assessment Program within the spruce decline of the Forest Response Program and will provide a broad basis from which to predict the growth and yield of the species within the forest types in the Northeast.

Expansion of the model to predict the growth response of forest stands under stress, will provide a basis for detecting the influence of atmospheric deposition, insect attacks, drought, etc. within the Spruce-Fir Forest Research Cooperative. Attempts are being made to incorporate the growth response of individual trees to the influence of environmental stress.

Workshops are being conducted throughout the New England states in order to provide instruction to forest managers. Involvement by foresters from state, federal, company and consultant disciplines attests to the broad application of the model.

Problem 4

**SOIL FERTILITY, SITE PRODUCTIVITY AND THE NUTRIENT
REQUIREMENTS OF MAJOR SPECIES
FY 87 Research Attainments**

Publications

Cooperative

Safford, L. O.; Czapowskyj, M. M. 1986. Fertilizer stimulates growth and mortality in a young Populus - Betula stand: 10-year results. Canadian Journal of Forest Research. 16 (4): 807-813.

Attainment

Cuttings of hybrid poplar clones NE-41 and NE-388 were planted on a drum-chopped, chip-harvested clearcut in eastern Maine. Soils were derived from coarse loamy glacial till. Soil acidity was less than pH 5 and soil moisture class was moderately well- to somewhat poorly drained. Control, lime (L), nitrogen (N), phosphorus (P), potassium (K) and combined treatments were established. Competing woody vegetation was mowed once per year for the first 3 years on half the area. Each mowed treatment produced significantly greater hybrid poplar biomass than the corresponding unmowed treatment. After 10 years, the mowed LNPK treatment attained the greatest biomass, 45 Mg/ha, while the unmowed control attained the least, 2 Mg/ha. On mowed plots, L produced 4 times the biomass of the control: 32 vs. 8 Mg/ha. Unmowed plots with L and N produced about as much hybrid poplar biomass as the mowed control (8 Mg/ha). Mowing improved survival as well as growth rates. Such information is valuable for selecting potential species and/or cultural procedures for artificial regeneration.

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4152

ECOLOGY AND MANAGEMENT OF CHERRY-MAPLE AND OAK FORESTS IN
THE ALLEGHENIES
MARQUIS, DAVID A., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. REGENERATION	TMR	331	3.0	5		
2. WILDLIFE HABITAT	WRFHR	62	.0	5		
3. GROWTH AND YIELD	TMR	280	3.0	8		

Problem 1

**REGENERATION
FY 87 Research Attainments**

Publications

Research Unit

Auchmoody, L. R. 1986. Land disposal of oil well brine. In: Management of oil and gas brines - the issues and challenges: 11th proceedings; 1986 October 28-29; Erie, PA. Syracuse, NY: State University of New York: 1-2.

Horsley, Stephen B. 1987. Allelopathic interference with regeneration of the Allegheny hardwood forest. In: Waller, G. R., ed. Allelochemicals: role in agriculture and forestry. American Chemical Society Symposium Series 330. 205-212.

Horsley, Stephen B. 1987. Evaluating the mechanism of hayscented fern interference. In: Marose, B.H., ed. Proceedings: 41st annual meeting northeastern weed science society; 1987 January 5-8; Williamsburg, VA. College Park, MD: Northeastern Weed Science Society: 58 p. Abstract.

Nelson, Brad; Auchmoody, L. R. 1987. Fertilization of young clearcuts. In: Deer, forestry, and agriculture: interactions and strategies of management; 1987 June 15-17; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 108-117.

Walters, R. S. 1987. Effect of site factors on oak regeneration after partial cutting. Agronomy Abstracts. 1987: 267-268.

Attainment

Multiple use of the Allegheny hardwood forest on the Allegheny Plateau has caused significant difficulty in regenerating the forest. Maintenance of a very large recreational deer population has resulted in establishment of dense ground covers of ferns and other herbaceous plants in forest understories and old forest openings. A paper summarizing evidence that these herbaceous plants, especially the ferns, interfere with establishment of desirable advance regeneration of tree species was presented at a symposium on Allelochemicals: Roles in Agriculture and Forestry. Investigations of the mechanisms of interference with regeneration between hayscented fern, the most important timber species, were summarized in another paper. When herbaceous plants are not present, intensive browsing by white-tailed deer and forest soil nutrient deficiencies often limit establishment of well-stocked thrifty stands of Allegheny hardwoods. A paper summarizing the use of aerial fertilization of young clearcuts to increase browse production and rapidly grow seedlings out of reach of deer was presented at a symposium on Deer, Forestry, and Agriculture. Oak regeneration usually is difficult to obtain either because few seedlings become established or established seedlings do not grow fast enough to compete successfully with other species. A paper summarized the effects of partial cutting, burning, herbicide treatment, and site factors on oak seedling establishment and seedling height growth 2 years after treatment.

Use of forest land for oil production has sometimes resulted in interference with regeneration where oil well brine water has been discharged on the forest floor. A paper presented to a meeting of oil and gas producers documented the rapid healing process following elimination of the brine source.

Problem 2**WILDLIFE HABITAT
FY 87 Research Attainments**

Publications**Research Unit**

Dorio, John C.; Marquis, D. A. 1986. White-tailed deer management in the Allegheny National Forest. In: Integrated pest management symposium for northern forests; proceedings of a symposium; 1986 March 24-27; Madison, WI. Madison, WI: University of Wisconsin: 303-313.

Marquis, David A. 1986. Integration of timber and wildlife in silvicultural prescription writing. In: 18th IUFRO World Congress; 1986 September 2-21; Ljubljana, Yugoslavia. Division 1, Volume II. International Union of Forestry Research Organizations: 565-573.

Marquis, David A. 1987. Silvicultural techniques for circumventing deer browsing. In: Deer, forestry, and agriculture: interactions and strategies for management; 1987 June 15-17; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 125-136.

Redding, Jim. 1987. Impact of deer on forest vegetation and timber production in northern Pennsylvania. In: Deer, forestry, and agriculture: interactions and strategies for management; 1987 June 15-17; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 23-32.

Tilghman, Nancy T. 1987. Maximum deer populations compatible with forest regeneration: An estimate from deer enclosure study in Pennsylvania. In: Deer, forestry, and agriculture: interactions and strategies for management; 1987 June 15-17; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 71. Abstract.

Attainment

It has been well documented that browsing by white-tailed deer can cause regeneration failures, delays in stand establishment, or a shift in species composition in third-growth cherry-maple stands on the Allegheny Plateau. A paper summarizing the impact deer have on forest vegetation and timber production on the Plateau was presented at a symposium on Deer, Timber and Agriculture. Methods currently employed to circumvent browsing damage and an analysis of the economic impacts deer are having on future stand development were also covered. Most of the circumvention techniques outlined in the above paper—fencing, fertilization, herbicides—while effective, are also costly. Often costs are compounded over long periods of time, limiting the practical usefulness of these measures. A second paper presented at the symposium specifies silvicultural circumvention techniques that do not require large investments to implement. Basically, it is simply a matter of overwhelming the deer with more food than they can consume. By selecting areas of high regeneration potential, using the shelterwood technique where appropriate, and maximizing the amount of cutting in an area, regeneration of new high value stands can be successful. Management guidelines, based upon measureable stand parameters normally collected during stand examination, are also presented. Timber and wildlife management plans are too often drawn up independently using inventory data collected separately for each resource. A recent paper describes a method of integrating both resources into the same planning process using a single inventory of existing conditions. A silvicultural decision-making system providing the analytical tools to evaluate the effects of any treatment on both resources is presented.

Problem 3

**GROWTH AND YIELD
FY 87 Research Attainments**

Publications

Research Unit

- Auchmoody, L. R. 1987. Evaluating growth responses to fertilization: Reply. *Canadian Journal of Forest Research*. 17 (1): 94.
- Linton, David; Marquis, David A. 1986. Computer model for silviculture in Allegheny hardwoods (SILVAH). *Pennsylvania Forests*. 76 (5): 7.
- Linton, David; Marquis, David A. 1986. Computer model for silviculture of Allegheny hardwoods (SILVAH). *Women in Forestry*. 8 (2): 29.
- Marquis, David A. 1986. SILVAH: A stand analysis, prescription, and management simulator program for hardwood stands in the Alleghenies. *The Compiler*. 4 (3): 42-46.
- Marquis, David A. 1986. SILVAH: A stand analysis, prescription, and management simulator program for hardwood stands in the Alleghenies. In: Wiant, Harry V.; Yandle, David O.; Kidd, William E., eds. *Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. Morgantown, WV: West Virginia State University: 224-240.*
- Redding, James. 1987. Allegheny hardwood silviculture training sessions have a new home and a revised program. *Pennsylvania Forests*. 77 (3): 2-3.
- Redding, James. 1987. Allegheny hardwood silviculture training sessions have a new home and revised program. *The Allegheny News*. Summer 1987: 8.
- Stout, Susan L.; Marquis, David A.; Ernst, Richard L. 1987. A relative density measure for mixed species stands. *Journal of Forestry*. 85 (7): 45-47.

Attainment

The major findings for this problem are: 1) Support for the silvicultural prescription writing process has been enhanced by the development of a new version of the SILVAH stand analysis, prescription, and management simulator program; and 2) tree-area ratio relative density equations are more flexible for use in stands of a variety of species compositions than other commonly used tools for assessing relative stand density.

Stand inventory data are input to the SILVAH program, which summarizes the inventory data, analyzes the data by comparing it to guidelines for critical stand parameters developed through research and matched to user- specified management objectives, and recommends a prescription, complete with marking guides if relevant.

The tree-area based relative density measure currently used in the Allegheny hardwood region has been tested on stands whose species composition ranges from those traditionally measured by the Central Hardwoods Guide or the Allegheny Hardwood Guide, to some with high proportions of red maple and northern red oak. The new measure assesses density well in all these stands, while the stocking guides are limited to specific species compositions. The new measure provides a better estimate of the relative density of stands with mixtures of species including red maple and northern red oak. The flexibility of tree-area ratio measures of relative density in stands with mixed species composition offers promise for development of a more universal way of assessing relative stand density.

Northeastern Forest Experiment Station
Trees and Timber Management Research
Research Work Unit 4153

MANAGEMENT AND UTILIZATION ALTERNATIVES FOR NON-INDUSTRIAL
PRIVATE FORESTS

KINGSLEY, NEAL P., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. TECHNIQUES WHICH SHOW THE CONSEQUENCES OF APPLYING ALTERNATIVE RESOURCE MANAGEMENT	TMR	327	2.0	3		1
2. TECHNIQUES FOR PREDICTING WOOD QUALITY AND VALUE DEVELOPMENT IN WOODLANDS.	FPHR	0	4.0	6	1	2
3. HOW THE NONINDUSTRIAL PRIVATE FOREST OWNER CAN EVALUATE FOREST MANAGEMENT	RREc	0	2.0	2		1

**Problem 1 TECHNIQUES WHICH SHOW THE CONSEQUENCES OF APPLYING
ALTERNATIVE RESOURCE MANAGEMENT
FY 87 Research Attainments**

Publications

- Research Unit Dale, Martin E.; Lutz, David. 1986. A field guide to quantity and value growth of upland oak. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 32 p.
- Hilt, Donald E.; Dale, Martin E. 1987. Effects of precommercial thinning on diameter growth in young central hardwood stands. In: 6th Central hardwood conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 24-26.
- Hilt, Donald E.; Teck, Richard M.; Gullett, Thomas F. 1987. Uses, types and availability of growth and yield models for the Central Hardwood Region. In: 6th Central hardwood conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 24-26.
- Cooperative Gansner, David A.; Dale, Martin E.; Herrick, Owen W.; Dickson, David R.; Lutz, David E. 1987. Silvicultural cutting opportunities in oak-hickory forests. Northern Journal of Applied Forestry. 4: 59-63.

Attainment

Thinning is the one silvicultural practice that has the most potential for influencing tree and stand growth and yield. A field guide was developed to provide forest managers with information on the expected quantity and value of wood before and after thinning. Future stand development is given in terms of volume and value 10 years later with or without thinning. The tabled information is presented in a user-friendly format. Information from the field guide was expanded to a regional basis to analyze silvicultural cutting opportunities in the oak-hickory forests of Pennsylvania. Analyses revealed a statewide timber bonanza for wood-using industries. The current potential cut from silvicultural thinning, regeneration, and harvest opportunities totals 58 million cords worth \$615 million.

Precommercial thinning increased the diameter growth of trees in young central hardwood stands. The heavier the thinning, the greater the response. Results suggest that pre-commercial thinning be delayed until age 20. This information will help users manage the mixed-species stands that develop after upland oak stands growing on good sites are harvested.

Results are communicated to users through publications, workshops, and on-site field tours. Application of results will improve the management of our central hardwood forests.

Problem 2

**TECHNIQUES FOR PREDICTING WOOD QUALITY AND VALUE
DEVELOPMENT IN WOODLANDS.
FY 87 Research Attainments**

Publications

Research Unit

Brisbin, Robert L.; Dale, Martin E. 1987. Estimating tree-quality potential in a managed white oak stand by Markov Chain analysis. *Canadian Journal of Forestry Research*. 17: 9-16.

Rast, Everette D.; Brisbin, Robert L. 1987. Estimating potential quality and product yield from tree to primary end product. In: *Eastern hardwoods: The resources, the industry, and the markets*; 1985 September 9-11; Harrisburg, PA. Harrisburg, PA: Forest Products Research Society: 139-143.

Rast, Everette D.; Brisbin, Robert L. 1987. Six-year effects of two late spring frosts on Appalachian hardwoods. *Northern Journal of Applied Forestry*. 4: 26-28.

Sonderman, David L. 1987. Stem-quality changes on mixed upland hardwoods after crop-tree release. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Sonderman, David L.; Rast, Everette D. 1987. Quality of thinned trees in even-aged, upland oak stands. *Northern Journal of Applied Forestry*. 4: 2.

Yaussy, D. A. 1987. Green lumber grade yields from sugar maple and basswood factory grade logs. *Northern Journal of Applied Forestry*. 4: 36-39.

Cooperative

Howard, A. F.; Yaussy, D. A. 1987. Multivariate regression model for predicting yields of grade lumber from yellow birch sawlogs. *Forest Products Journal*. 36 (11): 56-60.

Jensen, K. F.; Yaussy, D. A. 1986. Comparison of yellow poplar growth models on the basis of derived growth and analysis variables. *Tree Physiology*. 1: 217-222.

Extramural

Dennis, Kevin M.; Blankenhorn, Paul R.; Labosky, Peter; Riskel, Lester L. 1986. A drying study of 4/4 lumber from gypsy moth-killed red and white oak. *Forest Products Journal*. 36 (10): 41-46.

Attainment

In many central hardwood stands, forest managers are concerned about maintaining or improving the potential quality of future crop trees as well as increasing growth. Thinning practices have been shown to increase diameter and volume growth, but there have been few studies on the effects of thinning on product potential. The effect of thinning to various basal area levels on the limb-related defect development of 80-year-old white oak trees was analyzed by Markov Chain analysis. The expected number of limb-related defects were predicted by 5-year intervals for 40 years after thinning. Generally, severe thinnings may result in a decrease of tree quality, particularly in white oak. Managers can use this information to balance the increased growth potential from thinnings with the inherent quality potential of the stand before making decisions. Multivariate regression models were developed to predict green board-foot yields for the common grades of factory lumber processed from sugar maple, basswood, and yellow birch factory grade logs. Model coefficients can be used in computer programs for the purpose of sawmill simulations, economic analyses, or log-yard inventory systems.

Study results are transferred to users through publications, symposia, and workshops.

Problem 3

HOW THE NONINDUSTRIAL PRIVATE FOREST OWNER CAN
EVALUATE FOREST MANAGEMENT
FY 87 Research Attainments

Publications

Research Unit

Kingsley, Neal P. 1987. NIPF's: Looking into the galaxy. National Woodlands. January-February: 20-22.

Kingsley, Neal P.; DeBald, Paul S. 1987. Hardwood lumber and stumpage prices in two eastern hardwood markets: The real story. Res. Pap. NE-601. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 17 p.

Cooperative

Leak, William B.; Solomon, Dale S.; DeBald, Paul. 1987. Silvicultural guide for northern hardwood types in the Northeast (revised). Res. Pap. NE-603. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36 p.

Attainment

Study results revealed that substantial portions of the Northeast's nonindustrial private timberland is not suited to timber production - physically, geographically, or because of the attitudes and objectives of its owners. When small tracts, inaccessible areas, forestland within metropolitan areas and owner attitudes are considered, the area of potentially manageable timberland in the Northeast is probably fewer than 50 million acres. This means that the forestry profession needs to identify those ownerships which present a reasonable and viable opportunity for timber management. Collaterally, owners need to be made aware that forest management can accomplish many of their non-timber objectives and help them defray the expenses of forest ownership. Hardwood lumber and stumpage prices appear to have risen substantially between 1964 and 1985. However, deflating these prices shows that inflation wiped out these increases for most species in two hardwood lumber markets and in a stumpage market. Only red oak, ash, and black cherry lumber prices increased faster than the rate of inflation. Yellow-poplar, basswood, hard maple, and soft maple prices actually declined in real terms. This information will help nonindustrial private timber owners select the most valuable species for management.

Results are disseminated to users through publications, symposia and field workshops.

Northeastern Forest Experiment Station
Wildlife, Range, and Fish Habitat Research
Research Work Unit 4251

WILDLIFE COMMUNITIES AND HABITAT RELATIONSHIPS IN NEW
ENGLAND FORESTS (NEW ENGLAND WILDLIFE HABITAT)
DEGRAAF, RICHARD M., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. AVIAN RESPONSE TO INTERMEDIATE CULTURE AND HARVEST CUTTING PRACTICES IN NORTHERN HARDWOODS	WRFHR	90	1.0	5		1
2. MANAGING UNDERGROWTH FOR DIVERSITY AND ABUNDANCE OF MAMMALS	WRFHR	105	1.0	2		1
3. BIRD PREDATORS OF THE SPRUCE BUDWORM AND THEIR RESPONSE TO WITHIN-STAND SILVICULTURE	FIDR	91	.5			
4. REGENERATING BUDWORM-RESISTANT STANDS WHILE PROVIDING FOOD AND SHELTER FOR DEER	WRFHR	61	.5	1		1

Problem 1

**AVIAN RESPONSE TO INTERMEDIATE CULTURE AND HARVEST
CUTTING PRACTICES IN NORTHERN HARDWOODS
FY 87 Research Attainments**

Publications

Research Unit

DeGraaf, Richard M. 1986. Urban bird habitat relationships: application to landscape design. In: Transactions of the 51st North American wildlife and natural resources conference; 1986 March 24-26; Reno, NV. Washington, DC: Wildlife Management Institute: 232-248.

DeGraaf, Richard M. 1987. Breeding birds and gypsy moth defoliation: short-term responses of species and guilds. Wildlife Society Bulletin. 15 (2): 217-221.

DeGraaf, Richard M. 1987. Managing northern hardwoods for breeding birds. In: Managing northern hardwoods: Proceedings of a silvicultural symposium; 1986 June 23-25; Syracuse, NY. 87-03. Washington, DC: Society of American Foresters: 348-362.

DeGraaf, Richard M. 1987. Urban wildlife habitat research-application to landscape design. In: National symposium on urban wildlife; 1986 November 4-7; Chevy Chase, MD. Columbia, MD: National Institute for Urban Wildlife: 108-111.

DeGraaf, Richard M.; Chadwick, Nan L. 1987. Forest type, timber size class, and New England breeding birds. Journal of Wildlife Management. 51 (1): 212-217.

Cooperative

Tubbs, Carl H.; DeGraaf, Richard M.; Yamasaki, Mariko; Healy, William M. 1987. Guide to wildlife tree management in New England northern hardwoods. Gen. Tech. Rep. NE-118. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 30 p.

Attainment

Breeding birds in pole and mature sawtimber stands of 6 forest cover types were grouped by association with timber size class, forest cover type, interactions of timber size and type, and key habitat components that occur irrespective of stand condition or forest type. Thirty bird species showed different distributions by forest cover type, 3 species' distributions differed by timber size class, and 13 species' distributions were functions of the interaction of cover type and size class.

A 2-summer comparison of foliated and gypsy moth defoliated oak stands in central Pennsylvania yielded no differences in species richness between stands. There were no differences in abundances of foraging guilds between foliated and defoliated stands.

The general effects of urbanization on birds can be mitigated by retention of pre-development landscape features and selection of material for the planted environment. Retention of woodlots will provide habitat for some forest birds, especially cavity nesters. Suburbs containing remnants of closed-canopy, multi-layered forests will support avifaunas quite different from those with mature, but planted, trees and shrubs. In the planted environment, maximizing the crown volumes of trees and shrubs is likely the one management practice or goal that will yield the greatest increases in breeding bird species richness.

Problem 2

**MANAGING UNDERGROWTH FOR DIVERSITY AND ABUNDANCE
OF MAMMALS
FY 87 Research Attainments**

Publications

Research Unit

Healy, William M. 1987. Habitat characteristics of uneven-aged stands. In: Managing northern hardwoods: Proceedings of a silvicultural symposium; 1986 June 23-25; Syracuse, NY. 87-03. Washington, DC: Society of American Foresters: 338-347.

Healy, William M.; Brooks, Robert T.; Lyons, Paul J. 1987. Deer and forests on Boston's municipal watershed after 50 years as a wildlife sanctuary. In: Deer, forestry, and agriculture: interactions and strategies for management; 1987 June 15-17; Warren, PA. Warren, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 3-22.

Cooperative

Kimmel, Richard O.; Healy, William M. 1987. Imprinting: A technique for wildlife research. In: Perdix IV: Gray partridge workshop; 1986 September 29-October 4; Regina, Saskatchewan. Madelia, MN: Minnesota Department of Natural Resources: 39-52.

Attainment

The white-tailed deer is an important herbivore in eastern forests that can severely impact forest regeneration. Portions of the 86,000-acre Quabbin Reservation in central Massachusetts have maintained a large deer herd for about 40 years. Recent estimates of deer density ranged from 34 to 59 per square mile. White pine-northern red oak-red maple stands on the sanctuary have lower densities of trees, tree seedlings, and shrubs than comparable stands outside the sanctuary. Where thinning has occurred on the sanctuary, ferns and grasses dominate the undergrowth. In areas with few deer, fern cover decreased after thinning. The number of wildlife species present does not appear to have been affected by these changes in vegetation, but the relative abundance of small mammals has changed. The Sanctuary deer herd is compatible with forest management for water yield, but it severely limits the potential for timber management. Regeneration on the sanctuary may be adequate to perpetuate the current park-like oak stands, but it is inadequate to regenerate new oak stands following timber harvest.

There is an increasing interest in using uneven-age management in the Northeast. The general relationships between uneven-age silviculture and wildlife habitat were synthesized and presented at a Silvicultural Symposium on Managing Northern Hardwoods. Five habitat elements—herbage, browse, cover, mast, and cavities—were defined, and the relationships among the habitat elements and stand structure were described. The elements represent simplifications of complex ecological relationships that are useful for evaluating stand condition and making prescriptions.

Problem 3**BIRD PREDATORS OF THE SPRUCE BUDWORM AND THEIR
RESPONSE TO WITHIN-STAND SILVICULTURE
FY 87 Research Attainments**

Publications

none

Attainment

The spruce budworm is a natural component of spruce-fir ecosystems. Its populations have oscillated more or less periodically over the last 2 centuries. High density populations cause the loss of foliage on fir of 80 percent or more for 4 to 6 years. Spruce are generally defoliated less severely. Chemical controls have resulted in only short-term protection and a prolongation of infestations. Because budworms evolved with spruce-fir forests and chemical control efforts have been controversial, it is logical to search for natural enemies within the forest ecosystem that are responsible for regulating budworm populations at low densities. We tested the hypothesis that predation by forest dwelling birds maintains low-density budworm populations. The percentage of the budworm population consumed by birds decreased as budworm numbers increased. Birds consumed 84 percent of budworm larvae and pupae where budworm populations were low; 22 percent where budworm populations were intermediate between low and high density. Once fourth-instar larvae exceeded 1 million/ha, bird predation was ineffectual. Smaller species of birds exhibited a negatively accelerating functional feeding response to increasing numbers of spruce budworm; larger species showed an "s-shaped" feeding response curve. Blackburnian warblers consumed the most spruce budworm. Many species of woodland birds were effective predators of the spruce budworm. Bird predation reduces growth loss in spruce-fir forests.

Problem 4

**REGENERATING BUDWORM-RESISTANT STANDS WHILE
PROVIDING FOOD AND SHELTER FOR DEER
FY 87 Research Attainments**

Publications

Research Unit

Crawford, Hewlette S. 1986. Moose in eastern wilderness—a role for prescribed fire. In: Wilderness and natural areas in the eastern United States: A management challenge; 1985 May 13-15; Nacogdoches, TX. Nacogdoches, TX: Stephen F. Austin University: 67-70.

Cooperative

Stutzman, Warren L.; Crawford, Hewlette S. 1986. Estimation of the weight of vegetation using microwave transmission measurements. In: IEEE Transactions on Geoscience and Remote Sensing; 1986, November; GE-24. New York, NY: IEEE Geoscience and Remote Sensing Society: 1017-1020.

Attainment

Single-tree selection develops maximum vertical diversity. Group selection develops more horizontal diversity than single-tree but lessens the continuity of vertical diversity. A greater number of small, irregularly shaped, well spaced clearcuts provides superior horizontal diversity than do fewer large clearcuts. On a site with superior growth characteristics, more understory forage may be produced per year but for a fewer number of years. Vertical diversity will develop sooner on superior sites than on poorer sites. On the poorest sites, vertical diversity may develop only after many years; as a result, clearcutting of poor sites, regardless of size, is rated low for wildlife.

Intensity of cutting affects diversity by setting back the seral stage by different degrees and by limiting vertical diversity. The more stems remaining after a cut, the greater the residual vertical diversity and the fewer the seral stages that need to be repeated before stand maturity. Shelterwoods cause less drastic modification of the stand than do clearcuts. Removal of part of the understory vegetation eliminates food and cover. However, it may increase diversity, e.g., when making openings in dense conifer or hardwood regeneration, or decrease diversity, as when hardwoods are removed from conifer patches. If understory hardwoods grow solitarily or in scattered groups, removal of this component of the vegetation may decrease the food of deer and moose. However, when these plants grow densely over extensive areas, much of this food is unavailable to moose and deer because the animals do not penetrate into these patches.

Northeastern Forest Experiment Station
Watershed Management and Rehabilitation Research
Research Work Unit 4301

WATER RESOURCE PROTECTION IN CENTRAL APPALACHIAN FORESTS
HELVEY, JUNIOR D., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. MINIMIZING HYDROLOGIC IMPACTS OF SURFACE DISTURBANCES FROM FOREST ACCESS AND HARVEST OPERATIONS	WMR	101	1.0	4		
2. IMPACT OF ATMOSPHERIC DEPOSITION ON THE SOIL AND WATER RESOURCES OF APPALACHIAN FORESTS.	WMR	225	2.0	3	1	

Problem 1**MINIMIZING HYDROLOGIC IMPACTS OF SURFACE DISTURBANCES FROM FOREST ACCESS AND HARVEST OPERATIONS
FY 87 Research Attainments**

Publications**Research Unit**

Kochenderfer, J. N.; Helvey, J. D. 1987. Using gravel to reduce soil losses from minimum-standard forest roads. *Journal of Soil and Water Conservation*. 42 (1): 46-50.

Kochenderfer, J. N.; Helvey, J. D.; Wendel, G. W. 1987. Sediment yield as a function of land use in Central Appalachian Forests. In: VI Central Hardwood Forest Conference; 1987 February 23-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 497-502.

Kochenderfer, J. N.; Kidd, W. E. Jr.; Wendel, G. W. 1987. Video: Managing your woodlot using minimum-standard roads. Cooperative Extension Service, West Virginia University, Morgantown, WV.

Patric, J. H.; Helvey, J. D. 1986. Some effects of grazing on soil and water in the Eastern forest. In: Gen. Tech. Rep. NE-GTR-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 25 p.

Attainment

What is the best method to improve the utility of low cost logging roads while reducing stream pollution by eroded sediment? The obvious answer is to apply several inches of gravel on the road surface. The paper "Using gravel to reduce soil losses from minimum-standard forest roads" quantifies sediment losses over a 4-year period from roads built to different standards and surfaced with different sized gravel. Average annual soil losses ranged from 47 tons per acre on sections of ungraveled road to 6 tons per acre on road sections surfaced with a 6-inch deep layer of clean gravel ranging in size from 2 inches to 3 inches in diameter. Ungraveled road sections were severely rutted by logging trucks but graveled sections were not.

Non-point source pollution is a continuing concern for forest managers. The paper "Sediment yield as a function of land use in the Central Appalachian forests" helps define the range in annual soil losses. Measured annual losses were 31 lbs per acre from an undisturbed watershed; 166 lbs per acre from a watershed that was partially logged in 1977; and 253 lbs per acre from a watershed that was farmed for many years and then allowed to revegetate naturally after the early 1900s. All of these measured sediment yields from forested land were far below the 2 to 5 tons per acre per year generally accepted as tolerable from agricultural land.

A video on low cost logging road construction and maintenance was developed jointly by research Projects NE-4301 and NE-4101 and the West Virginia Extension Service. It will have widespread distribution to students, loggers, foresters, land owners, and the general public throughout the Appalachians.

Problem 2

**IMPACT OF ATMOSPHERIC DEPOSITION ON THE SOIL AND
WATER RESOURCES OF APPALACHIAN FORESTS.
FY 87 Research Attainments**

Publications

Research Unit

Edwards, Pamela J. 1986. Conversion factors and constants used in forestry, with emphasis on water and soil resources. In: Gen. Tech. Rep. NE-GTR-113. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 12 p.

Helvey, David J.; Kochenderfer, James N. 1987. Effects of limestone gravel on selected chemical properties of road runoff and streamflow. *Northern Journal of Applied Forestry*. (4): 23-25.

Helvey, J. D.; Edwards, Pamela J. 1987. Time trends of precipitation and streamflow chemistry at the Fernow Experimental Forest. In: Aquatic Effects Task Group VI Peer Review Summaries; 1987 May 18-22; New Orleans, LA. Raleigh, NC: North Carolina Stat Univ.: 413-420.

Extramural

Richards, R. Peter; Kramer, Jack W.; Baker, David B.; [and others]. 1987. Pesticides in rainwater in the northeastern United States. *Nature*. 327 (6118): 129-131.

(Project collected precipitation samples and shipped them to Heidelberg College, Tiffin, Ohio, for analysis.)

Attainment

What is the relationship between equivalents per hectare, kilograms per hectare, pounds per acre, milligrams per square meter and milligrams per liter? Each of these units has been reported in the contemporary literature to express nutrient loadings on watersheds. Units of length, area, volume, and mass also vary between publications. For many people unfamiliar with these different units of measure, published results are difficult or impossible to compare. To help remedy this situation, a paper "Conversion factors and constants used in forestry, with emphasis on water and soil resources" was published in 1987. This reference gives easily understood conversion factors for all units of measure expected to be encountered in the literature on soil and water.

Many streams in the Central Appalachians are too acidic to support trout populations. The paper "Effects of limestone gravel on selected chemical properties of road runoff and streamflow" tested the following hypothesis. A heavy application of limestone gravel to logging roads that are located close to acid streams will improve the chemical water quality of these streams. The study showed that road runoff was much higher in calcium content, but the volume of road runoff was too small to change the chemistry of stream water. If the objective is to increase alkalinity sufficiently for trout survival, the best method is to install stream-powered rotating drums that are filled with crushed limestone. This method has been successfully used for several years by the West Virginia Department of Natural Resources.

Northeastern Forest Experiment Station
Watershed Management and Rehabilitation Research
Research Work Unit 4302

RECLAMATION OF SURFACE-MINED AREAS
HALVERSON, HOWARD G., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. MORE INFORMATION IS NEEDED ON OVERBURDEN AND SPOIL PROPERTIES.	WMR	150	1.2	3		1
2. STREAMFLOW AND WATER QUALITY AS RELATED TO OVERBURDEN CHARACTERISTICS AND RECLAMATION	WMR	288	1.1	2	1	2
3. TECHNIQUES NEEDED FOR REVEGETATION WITH WOODY SPECIES FOR WILDLIFE HABITAT AND REFORESTATION.	WMR	341	1.7	4		2
4. EFFECTS OF SURFACE MINING AND RECLAMATION ALTERNATIVES ON LANDSCAPE QUALITY.	WMR	0	.0			

Problem 1**MORE INFORMATION IS NEEDED ON OVERBURDEN AND SPOIL PROPERTIES.****FY 87 Research Attainments**

Publications**Research Unit**

Davidson, Walter H. 1986. Predicting tree survival and growth from minesoil analysis. In: Forests, the world, and the profession: Proceedings of the 1986 Society of American Foresters national convention; 1986 October 5-8; Birmingham, AL. Bethesda, MD: Society of American Foresters: 244-246.

Melhuish, J.H., Jr.; Willis, R.B.; Wright, C.S. 1986. Separation and identification of phenolic acids and related compounds by gas chromatography and fourier transform infrared spectroscopy. *Journal of Chemical Ecology*. 13 (2): 317-323.

Willis, Raymond B.; Gentry, Claude E. 1987. Automated method for determining nitrate and nitrite in water and soil extracts. *Communications in Soil Science and Plant Analysis*. 18 (6): 625-636.

Cooperative

Beckjord, Peter R.; Melhuish, John H., Jr.; Hacskeylo, Edward. 1986. Ectomycorrhiza formation on sawtooth oak by inoculation with basidiospore chips of *Pisolithus tinctorius* and *Scleroderma citrinum*. *Journal of Environmental Horticulture*. 4 (4): 127-129.

Attainment

Minesoil characteristics often create hostile environments for vegetation, especially trees. The substrate materials are often acidic and quite low in essential plant nutrients. Research has shown that soil pH is a major factor in predicting survival of several of the tree species commonly used in mine reclamation. But pH alone gives only an inexact prediction of successful tree establishment. Survival predictions for conifers were improved by incorporating conductance and manganese concentrations, as well as pH, into the prediction process. For hardwoods, adding values of exchangeable acidity, exchangeable aluminum, exchangeable hydrogen, potassium, and phosphorus to the prediction scheme improved the results. This information will be helpful in prescribing tree species to plant on future mine sites. Forest vegetation also increases the rate at which acid sites ameliorate if an organic layer develops. The moderation of acidic conditions suggests that organic mulches, used to enhance revegetation and reduce erosion, may also provide the benefit of improving soil pH.

Problem 2**STREAMFLOW AND WATER QUALITY AS RELATED TO
OVERBURDEN CHARACTERISTICS AND RECLAMATION
FY 87 Research Attainments**

Publications**Research Unit**

Curtis, Willie R.; Dyer, Kenneth L.; Williams, George P., Jr. 1986. A manual for training reclamation inspectors in the fundamentals of hydrology. Ankeny, IA: Soil Conservation Society of America; 56 p.

(This was prepared for the U. S. Department of the Interior, Office of Surface Mining and Enforcement, Washington, DC by the U. S. Department of Agriculture, Forest Service, Berea, KY and printed by the Soil Conservation Society of America, Ankeny, IA.)

Vogel, Willis G. 1987. A manual for training reclamation inspectors in the fundamentals of soils and revegetation. Ankeny, IA: Soil and Water Conservation Society; 178 p.

(This was prepared for the U. S. Department of the Interior, Office of Surface Mining and Enforcement, Washington, DC by the U. S. Department of Agriculture, Forest Service, Berea, KY and printed by the Soil and Water Conservation Society, Ankeny, IA.)

Cooperative

Becker, Charles W.; Woods, Frank W.; Curtis, Willie R. 1986. Water quality of mined and unmined watersheds in east Tennessee. Journal of the Tennessee Academy of Science. 61 (4): 98-104.

Woods, Frank W.; Becker, Charles W.; Curtis, Willie R. 1986. Recovery of water quality after strip mining. Tennessee Farm and Home Science. 140: 10-13.

Extramural

Becker, Charles W. 1987. Stream water quality in east Tennessee. Knoxville, TN: The University of Tennessee. 180 p. M.S. thesis.

Attainment

Mining activities are usually thought to cause degraded water quality in streams draining the mined area. However, research has shown that unmined watersheds do not always yield higher quality water. In one study, an unmined watershed yielded water of poorer quality than an adjacent mined watershed. The source of the contamination was apparently a road. Also, older mines yielded higher quality water than new mines, suggesting that proper reclamation can improve water quality. Yet, some mines do cause water quality problems. There has been research on both the watershed conditions that result in water quality problems and on reclamation techniques to improve water quality. The results of this research were available but only from a variety of sources. This scattered information, especially on water quality problems and remedial techniques, has now been assembled into a single reference document. The material is suitable as an instruction manual as well as a reference work.

This information is used as an instructional manual for a reclamation hydrology course that is jointly sponsored by State and Private Forestry and the Office of Surface Mining. The course was presented to nine groups during 1987. There have been other presentations of this material at meetings for users.

Problem 3**TECHNIQUES NEEDED FOR REVEGETATION WITH WOODY SPECIES FOR WILDLIFE HABITAT AND REFORESTATION.
FY 87 Research Attainments**

Publications**Research Unit**

Davidson, Walter H. 1986. A renewed interest in white pine. *Green Lands*. 16 (2): 32-33.

Melhuish, J.H., Jr.; Beckjord, P.R.; Vogel, W.G. 1987. Flowering requirements of *Tussilago farfara*. *Transactions of the Kentucky Academy of Science*. 48 (1-2): 1-4.

Vogel, Willis G.; Rothwell, Frederick M. 1986. Bark mulch aids establishment of black walnut planted on western Kentucky mine spoils. In: Kolar, Clay A., ed. *Better reclamation with trees: Proceedings of the 5th annual conference*; 1985 June 5-7; Carbondale, IL. Carbondale, IL: Amax Coal Company: 104-110.

Wade, Gary L.; Crews, Jerry T.; Vogel, Willis G. 1986. Development and productivity of forest plantations on a surface mine in southeastern Kentucky. In: Kolar, Clay A., ed. *Better reclamation with trees: Proceedings of the 5th annual conference*; 1985 June 5-7; Carbondale, IL. Carbondale, IL: Amax Coal Company: 184-193.

Cooperative

Bowers, Lynne J.; Melhuish, John H., Jr. 1987. Elemental analysis of red oak and loblolly pine growing near an inactive chromium smelter. In: Hay, Ronald L.; Woods, Frank W.; DeSelm, Hal, ed. *Proceedings, 6th central hardwood forest conference*; 1987 February 24-26; Knoxville, TN. Knoxville, TN: The University of Tennessee: 231-245.

Keys, Roy N.; Cech, Franklin C.; Davidson, Walter H. 1986. Nutrient content and growth of an Austrian pine (*Pinus Nigra* Arnold), seed source study on surface mine spoils. In: 1986 National symposium on mining, hydrology, sedimentology, and reclamation; 1986 December 8-11; Lexington, KY. UKY BU142. Lexington, KY: University of Kentucky: 267-274.

Attainment

Cultural practices can be used to enhance survival and early growth of trees introduced into mined areas. For example, mulching with shredded hardwood bark improved the survival of black walnut to 58 percent from 17 percent for unmulched trees. Mulching, however, did not improve height growth. After initial establishment other cultural practices may be needed to sustain vigorous tree growth. A study of hardwoods, other than black walnut, and conifer species on a mine site showed excellent growth but severe overstocking. Hardwood site index ranged from 55 (white oak) to 90 feet (yellow poplar) and were only slightly lower than hardwood site indices on undisturbed areas adjacent to the mine. Pine site indices ranged from 65 to 90 feet, also near expected values for unmined sites. None of the mined sites received any supplemental nutrients to enhance height growth. The number of stems per acre averaged greater than 1000, indicating thinning might be beneficial in the future.

Results of this research were communicated to users through presentations and regional and national meetings as well as through publication. This information is also used in training sessions jointly sponsored by State and Private Forestry and the Office of Surface Mining. Seven training sessions were held during the last year.

Problem 4

**EFFECTS OF SURFACE MINING AND RECLAMATION
ALTERNATIVES ON LANDSCAPE QUALITY.
FY 87 Research Attainments**

Publications

none

Attainment

Work on this problem has not progressed due to changes in personnel.

Northeastern Forest Experiment Station
Watershed Management and Rehabilitation Research
Research Work Unit 4351

PHYSICAL AMENITIES AND WATER SUPPLIED BY URBAN AND
COMMUNITY FORESTS AND MUNICIPAL WATERSHEDS ENVIRONMENT
CORBETT, EDWARD, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. USING TREES AND FORESTS TO REDUCE ENERGY NEEDS AND ABATE NOISE.	WMR	149	.9	4		
2. ATMOSPHERIC DEPOSITION AND LAND USE PRACTICES ON WATER QUALITY IN MUNICIPAL WATERSHEDS.	WMR	180	1.0	3		4
3. CYCLING OF MATERIALS INCLUDED IN ATMOSPHERIC DEPOSITION IN URBAN FORESTS.	WMR	0	.0			
M1. WATERSHED STUDY ON THE DILLDOWN UNIT OF THE DELAWARE-LEHIGH EXPERIMENTAL FORESTS	WMR	10	.1			

Problem 1

**USING TREES AND FORESTS TO REDUCE ENERGY NEEDS AND
ABATE NOISE.
FY 87 Research Attainments**

Publications

Research Unit

Heisler, G.M.; McDaniel, O.H.; Hodgdon, K.K.; Portelli, J.J.; Gleason, S.B. 1987. Highway noise abatement in two forests. In: Tichy, J.; Hayek, S., eds. NOISE-CON 87: Proceedings of 1987 national conference on noise control engineering; 1987 June 8-10; State College, PA. New York: Noise Control Foundation: 465-470.

Heisler, Gordon M. 1986. Trees and energy use. In: Trees are for everyone: Proceedings, 20th annual meeting of Society of Municipal Arborists; 1984 September 30-October 3; Freehold, NJ. St. Paul, MN: Society of Municipal Arborists: 11-24.

Heisler, Gordon M.; Grant, Richard H. 1987. Predicting pedestrian-level winds in cities. In: Proceedings 8th national conference on biometeorology and aerobiology; 1987 September 16-18; West Lafayette, IN. Boston, MA: American Meteorological Society: 356-359.

Sullenberger, Diane; Heisler, Gordon. 1986. Using trees to reduce energy consumption. Pennsylvania Forests. 76(4):6. [Also in New York Forester. 43(2):15].

Attainment

Trees and forests within or adjacent to human developments influence both microclimatic and acoustic environments in ways that can be beneficial to people, but inadequate management may lead to lost benefits or even adverse influences. A review of Forest Service and other research indicated the degree to which heat transmission into and out of houses can be influenced by trees, how to locate trees to maximize solar radiation on a house in winter while minimizing it in summer, and the approximate magnitude of shade tree and windbreak effects on energy use in houses. Measurements in the business district of Dayton, Ohio, yielded regression models that explained about 50 percent of the variation in wind speed using parameters to describe building morphology and nearby trees along with wind conditions at the airport. The models showed that even newly planted trees measurably reduced windspeed. Similar methods can be used in residential neighborhoods to separate the effects on wind of houses from the effects of trees, and the resulting models can be extrapolated to other cities. In measurements of sound attenuation by forests, a 100-m-wide forest of mostly leafless deciduous trees caused no apparent attenuation, while a red pine plantation of the same width reduced traffic noise by an amount (8 dBA) that equaled predicted attenuation by a 4-m wall 10 m from the highway.

Distribution of research results included presentations to municipal arborists, forest- and bio-meteorologists, and noise control engineers. Other technology transfer was by brief articles for foresters and consultations with DOE staff and state foresters. This problem has national importance because 35-40 billion dollars is spent each year to heat and cool single-family homes.

Problem 2

**ATMOSPHERIC DEPOSITION AND LAND USE PRACTICES ON
WATER QUALITY IN MUNICIPAL WATERSHEDS.
FY 87 Research Attainments**

Publications

Research Unit

Corbett, Edward S.; Lynch, James A. 1987. Frequency and magnitude of episodic stream pH depressions on a forested watershed. In: Aquatic effects task group VI peer review: National Acid Precipitation Assessment Program; 1987 May 17-23; New Orleans, LA. Raleigh, NC: North Carolina State University: 7 p.

Corbett, Edward S.; Lynch, James A. 1987. Long-term trend analysis of streamflow pH on a forested watershed. In: Aquatic effects task group VI peer review: National Acid Precipitation Assessment Program; 1987 May 17-23; New Orleans, LA. Raleigh, NC: North Carolina State University: 8 p.

Corbett, Edward S.; Lynch, James A. 1987. The gypsy moth – does it affect soil and water resources?. In: Fosbroke, Sandra; Hicks, Ray R., Jr., eds. Coping with the gypsy moth in the new frontier: Proceedings of a symposium; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University Books: 39-46.

Cooperative

Lynch, James A.; Corbett, Edward S. 1987. Assessing methods of estimating sulfate export from a forested watershed. In: Aquatic effects task group VI peer review: National Acid Precipitation Assessment Program; 1987 May 17-23; New Orleans, LA. Raleigh, NC: North Carolina State University: 8 p.

Lynch, James A.; Corbett, Edward S. 1987. Predicting stream chemistry changes due to episodes – modeling atmospheric deposition cycling through a forested ecosystem. In: Aquatic effects task group VI peer review: National Acid Precipitation Assessment Program; 1987 May 17-23; New Orleans, LA. Raleigh, NC: North Carolina State University: 8 p.

Lynch, James A.; Corbett, Edward S.; Kostelnik, Kevin M. 1986. Atmospheric deposition: spatial and temporal variation in Pennsylvania 1985. University Park, PA: The Pennsylvania State University, Institute for Research on Land and Water Resources; LW8609. 81 p.

Lynch, James A.; Corbett, Edward S.; Kostelnik, Kevin M. 1986. Atmospheric deposition: spatial and temporal variation in Pennsylvania 1985. University Park, PA: The Pennsylvania State University, Institute for Research on Land and Water Resources; LW8609A. 239 p.

Attainment

To evaluate impacts of gypsy moth defoliation on water quality, water samples were collected from three pristine forest streams on the Buchanan State Forest in Pennsylvania. Increasing densities of indicator organisms were found on the study watersheds during defoliation periods. Fecal streptococci densities as high as 25,000/100 ml were observed in stream samples during periods of active defoliation, while fecal coliform and total coliform densities exceeded 90/100 ml and 400/100 ml respectively on occasion. The fecal coliform/fecal streptococci ratios indicate that these indicator organisms were from non-human sources. These data indicate that defoliation residues could be a potential contamination source for municipal water supplies. Over a four year period an average of 33 episodic stream pH depressions of 0.3 pH units or greater occurred per year. The maximum storm caused stream pH depression was 2.37 pH units (7.32 to 4.95) occurring in October following a dry period. The frequency of occurrence of stream pH depressions increased from January (lowest) to June (highest) and then decreased through December. During the study period, storm caused pH depressions of 1.26 pH units or greater occurred at least once for all months except January and September. Frequency and magnitude of episodic pH depressions may thus be important factors in assessing aquatic habitat suitability. Precipitation in Pennsylvania in 1985 was generally more acidic than any other region in the United States. Volume-weighted mean pH of precipitation in Pennsylvania during 1985 was 4.09 and varied from 4.18 to 3.98 at the 16 monitoring sites. The lowest pH measured was 3.23. Wet sulfate deposition ranged from 22.5 to 41.5 kg/ha/yr and was well correlated with pH. The highest sulfate concentrations in the State occurred in the areas of greatest sulfur dioxide emissions.

Problem 3**CYCLING OF MATERIALS INCLUDED IN ATMOSPHERIC
DEPOSITION IN URBAN FORESTS.
FY 87 Research Attainments**

Publications

none

Attainment

Forests in and near urban areas provide many benefits, such as reduced fuel needs in homes, reduced noise levels, and improved water quality if suitable forest vegetation is managed properly. Three coniferous species (pitch pine, Austrian pine, and Norway spruce) can be successfully established on soils with bulk densities up to 1.6 g/cubic cm if soil moisture is maintained near field capacity. Energy balance studies suggest that urban trees are under greater water deficit stress than trees located away from cities. Trees in the urban forest require 1.55 times as much water as non-urban trees due to sensible heat created in urban areas and advected into the forests. A study of an urban forest ecosystem showed that 10 to 25 percent of the nitrogen, 25 percent of the sulfate, but less than 5 percent of other plant nutrients in throughfall originated in precipitation. Other surfaces in urban forests, ranging from residential areas to central business districts, did not increase loads of N, P or K in runoff. However, runoff loads of Sulfate, Ca, Pb, Zn, Fe, and Al were increased in areas of major development and heavy traffic. Crown cover accounted for 38 percent of the surface area of small towns, population about 2000, and 21 percent in large communities, population near 200,000. Crown cover was low in central business districts and near major highways but high in residential areas where nearly a quarter of the residential street surface was below a tree crown. Small to medium sized communities developed in forests may have less effect on water quality than expected because they retain a large percentage of natural surfaces. Tree crown cover declined and impervious cover increased with increases in a cities' population. A reference workbook was prepared to transmit the information along with published journal articles and personal contacts.

Problem M1**WATERSHED STUDY ON THE DILLDOWN UNIT OF THE
DELAWARE-LEHIGH EXPERIMENTAL FORESTS
FY 87 Research Attainments**

Publications

none

Attainment

None. This is a long-term study of the effects of vegetation conversion on hydrologic response. No activities other than data collection and maintenance were scheduled this year.

Northeastern Forest Experiment Station
Watershed Management and Rehabilitation Research
Research Work Unit 4352

IMPACT OF FOREST MANAGEMENT AND ACID PRECIPITATION ON
NUTRIENTS IN SOIL AND WATER
PIERCE, ROBERT S., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. EFFECTS OF TIMBER HARVESTING PRACTICES ON SOIL NUTRIENTS, PARTICULARLY NITROGEN	WMR	600	3.0	14		4
2. NEED TO QUANTIFY THE IMPACTS OF ACID PRECIPITATION ON SOIL AND WATER CHEMISTRY	TMR	144	3.0	9		4
M1. HBEF WILL BE MAINTAINED AS A BIOSPHERE RESERVE AND DATA AND KNOWLEDGE MADE AVAILABLE TO OTHERS	WMR	68	.4	2	16	3

Problem 1

**EFFECTS OF TIMBER HARVESTING PRACTICES ON SOIL
NUTRIENTS, PARTICULARLY NITROGEN
FY 87 Research Attainments**

Publications

Research Unit

Hornbeck, J.W. 1986. Nutrient cycles and forest productivity. In: Proceedings of the 1986 symposium on the productivity of northern forests following biomass harvesting; 1986 May 1-2; Durham, NH. Gen. Tech. Rep. NE-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 23-27.

Hornbeck, J.W.; Martin, C.W.; Pierce, R.S.; Bormann, F.H.; Likens, G.E.; Eaton, J.S. 1986. Clearcutting northern hardwoods: effects on hydrologic and nutrient ion budgets. *Forest Science*. 32 (3): 667-686.

Hornbeck, J.W.; Martin, C.W.; Pierce, R.S.; Bormann, F.H.; Likens, G.E.; Eaton, J.S. 1987. The northern hardwood forest ecosystem: Ten years of recovery from clearcutting. Res. Pap. NE-596. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 30 p.

Hornbeck, J.W.; Martin, C.W.; Smith, C.T. 1986. Protecting forest streams during whole-tree harvesting. *Northern Journal of Applied Forestry*. 3: 97-100.

Hornbeck, J.W.; Martin, C.W.; Tritton, L.M.; Pierce, R.S.; Smith, C.T. 1987. Changes in nutrient outputs in streamflow after harvesting central hardwoods. In: 6th central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: The University of Tennessee: 479-485.

Martin, C.W. 1986. Biomass harvesting, soil disturbance, and regeneration. In: Proceedings of the 1986 symposium on the productivity of northern forests following biomass harvesting; 1986 May 1-2; Durham, NH. Gen. Tech. Rep. NE-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 39-42.

Martin, C.W. 1986. Silvicultural prescriptions affect the nutrient status of northern hardwood forests. In: Symposium on the northern hardwood resource: management and potential; 1986 August 18-21; Houghton, MI. Houghton, MI: Michigan Technological University: 250-259.

Martin, C.W.; Tritton, L.M.; Hornbeck, J.W. 1987. Revegetation after whole-tree clearcutting of hardwoods in Connecticut. In: 6th central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: The University of Tennessee: 119-126.

Tritton, L.M. 1986. Rapid decay of slash in northern hardwood forests. *Ecological Society of America Annual Meeting*. 67(2):333. Abstract.

Tritton, Louise M.; Martin, C. Wayne; Hornbeck, James W.; Pierce, Robert S. 1987. Biomass and nutrient removals from commercial thinning and whole-tree clearcutting of central hardwoods. *Environmental Management*. 11 (5): 659-666.

Tritton, Louise M. 1987. Book review, "Soil Biotechnology Microbial Factors in Crop Productivity." *Applied Biochemistry and Biotechnology*. 14(1):73-74.

Tritton, Louise M.; Martin, C. Wayne; Hornbeck, James W.; Pierce, Robert S.; Smith, C. Tattersall, Jr. 1987. Whole-tree clearcutting as perturbation of the forest ecosystem. *Bulletin of the Ecological Society of America*. 68(3):433. Abstract.

Yawney, H.W.; Bickelhaupt, D.H.; Briggs, R.D. 1986. Sampling variation in glacial till soils in Vermont. In: American Society of Agronomy Annual Meeting; 1986 November 30-December 5.; New Orleans, LA. Agronomy Abstracts. 269. Abstract.

Yawney, Harry W. 1986. Planting sugar maple. *New England Farmer*. October: B2-B3.

Cooperative

Briggs, R.D.; Cunia, T.; White, E.H.; Yawney, H.W. 1987. Estimating sample tree biomass by subsampling. In: Faculty of Forestry Misc. Publ. No. 12. Syracuse, NY: SUNY College of Environmental Science and Forestry: 48.

Briggs, R.D.; Cunia, T.; White, E.H.; Yawney, H.W. 1987. Estimating sample tree biomass by subsampling: Some empirical results. In: The workshop on tree biomass regression functions and their contributions to the error of forest inventory estimates; 1986 May 26-30; Syracuse, NY. Gen. Tech. Rep. NE-117. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-128.

Briggs, R.D.; White, E.H.; Yawney, H.W. 1986. Sampling trailers for estimating moisture content and nutrient concentrations for hardwood chips. Northern Journal of Applied Forestry. 3: 156-158.

Smith, C. Tattersall; Martin, C. Wayne; Tritton, Louise M., tech eds. 1986. Proceedings of the 1986 symposium on the productivity of northern forests following biomass harvesting.; 1986 May 1-2; Durham, NH. Gen. Tech. Rep. NE-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 104 p.

Attainment

Two even-aged management systems, progressive strip cutting and block clearcutting, have been studied at the Hubbard Brook Experimental Forest, New Hampshire. In the strip cutting, all merchantable trees were harvested in a series of three strips over four years. In the block clearcutting, all trees were harvested in a single operation. By the 10th year after harvest, hydrologic and nutrient budgets had returned nearly to preharvest levels, and a closed canopy had formed on both cut areas. Both types of cutting represent a severe disturbance to the forest ecosystem. However, studies of these watersheds indicate that if forest managers insure that care is taken during logging, and if sawtimber rotation lengths are followed, there should not be major adverse impacts on site nutrient capital, stand regeneration, or productivity. Compared with block clearcutting, progressive strip cutting moderates impacts on hydrologic and nutrient cycles, and may result in a more desirable mix of commercial species in the new stand. Thus forest managers may wish to use progressive strip cutting on less fertile sites. This technology was communicated via published articles and oral presentations designed to reach an audience ranging from practicing foresters to forest researchers.

Problem 2

NEED TO QUANTIFY THE IMPACTS OF ACID PRECIPITATION ON SOIL AND WATER CHEMISTRY

FY 87 Research Attainments

Publications

Research Unit

Federer, C. Anthony; Hornbeck, James W. 1987. Expected decrease in diameter growth of even-aged red spruce. *Canadian Journal of Forest Research*. 17: 266-269.

Federer, C. Anthony; Hornbeck, James W. 1987. Red spruce diameter growth and Weibull functions for even-aged stand development. In: *International symposium on ecological aspects of tree-ring analysis*; 1986 August 18-21; Tarrytown, NY. Washington, D.C.: United States Department of Energy Press CONF-8608144: 18-25.

Hornbeck, J.W. 1987. Growth patterns of red oak and red and sugar maple relative to atmospheric deposition. In: *6th central hardwood forest conference*; 1987 February 24-26; Knoxville, TN. Knoxville, TN: The University of Tennessee: 277-282.

Hornbeck, J.W.; Federer, C.A. 1987. A forestry approach to tree rings and red spruce growth decline. In: *Tree rings and forest mensuration: How can they document trends in forest health and productivity?*; National Council of the Paper Industry for Air and Stream Improvement. Tech. Bull. No. 523: 32-33.

Hornbeck, J.W.; Smith, R.B.; Federer, C.A. 1986. Growth decline in red spruce and balsam fir relative to natural processes. *Water, Air, and Soil Pollution*. 31: 425-430.

Hornbeck, J.W.; Smith, R.B.; Federer, C.A. 1987. Growth decline in red spruce and balsam fir relative to natural processes. In: *Acidic precipitation: Part II*; Boston, MA: D. Reidel Publishing Co.: 425-430.

Hornbeck, J.W.; Smith, R.B.; Federer, C.A. 1988. Extended growth decreases in New England are limited to red spruce and balsam fir. In: *International symposium on ecological aspects of tree-ring analysis*; 1986 August 18-21; Tarrytown, NY. Washington, DC: U.S. Department of Energy. CONF-8608144: 38-44.

Krusic, P.J.; Kenney, M.; Hornbeck, J.W. 1987. Preparing increment cores for ring-width measurements. *Northern Journal of Applied Forestry*. 4 (2): 104-105.

Smith, R.B.; Hornbeck, J.W.; Federer, C.A. 1986. What is happening to New Hampshire's red spruce?. *Forest Notes*. Fall: 27, 32.

Cooperative

Bailey, S.; Hornbeck, J.W.; Martin, C.W.; Buso, D.C. 1987. Watershed factors affecting stream acidification in the White Mountains of New Hampshire. *Environmental Management*. 11 (1): 53-60.

Baird, F.; Buso, D.C.; Hornbeck, J.W. 1987. Acid pulses from snowmelt in acidic Cone Pond, NH. *Water, Air, and Soil Pollution*. 34: 325-338.

Jacoby, G.; Hornbeck, J.W., tech. eds. 1987. *Proceedings of the international symposium on the ecological aspects of tree ring analysis*; 1986 August 17-21; Tarrytown, NY. Washington, DC: U.S. Department of Energy. CONF-8608144. 726 p.

Smith, C.T.; Hornbeck, J.W.; McCormack, M.L., Jr. 1987. Nutrient concentrations in soil solution increase after herbicide release of spruce fir regeneration. *Bulletin of the Ecological Society of America*. 68(2):418. Abstract.

Attainment

Measurements of tree rings from over 5,000 trees confirm growth decreases for red spruce since 1960 and balsam fir since 1965, but eight other species, including hemlock and white pine and six major hardwoods show either constant or increasing growth rates. Normal aging has been found to be a probable cause for decreasing growth rates in red spruce and balsam fir, confounding the efforts to separate impacts of atmospheric deposition. Studies of acidic Cone Pond (pH 4.5) in the White Mountains of New Hampshire showed that inputs of acid pulses during snowmelt remain near the pond surface and pass quickly through the outlet. However, mineral materials in the Cond Pond watershed provide little buffering, allowing the strong mineral acids in precipitation to acidify streams and pond water. Nearby watersheds with more reactive minerals have ponds and streams much more resistant to acid precipitation. A method was devised to determine quickly the potential influence of bedrock type to aquatic chemistry. The baseline data on tree growth and acidification of aquatic ecosystems serve as a basis for decisions about future research, and for developing legislation and controls relative to the major national problem of atmospheric deposition. The information from the tree-ring studies was featured in the 1987 Annual Report to the President and Congress, prepared by the National Acid Precipitation Assessment Program.

Problem M1

**HBEF WILL BE MAINTAINED AS A BIOSPHERE RESERVE AND
DATA AND KNOWLEDGE MADE AVAILABLE TO OTHERS
FY 87 Research Attainments**

Publications

Research Unit

Northeastern Forest Experiment Station. 1986. (Written by L.M. Tritton and R.S. Pierce). Hubbard Brook Experimental Forest. NE-INF-71-86. Broomall, PA: U.S. Department of Agriculture, Forest Service; Northeastern Forest Experiment Station. 15 p.

Pierce, R.S.; Siccama, T.G. 1986. Hubbard Brook Experimental Forest background and synthesis. In: Coupling of ecological studies with remote sensing: Potential at four biosphere reserves in the United States.; Washington, D.C.: U.S. Man and the Biosphere Program, Department of State. Publ. 9504: 43-51.

Cooperative

Bormann, F.H.; Bowden, W.B.; Pierce, R.S.; Hamburg, S.P.; Ingersoll, R.C.; and others. 1987. The Hubbard Brook sandbox experiment. In: Restoration ecology: a synthetic approach to ecological research.; Great Britain: Cambridge University Press: 251-256.

Germann, P.F.; Pierce, R.S.; Bevin, K. 1986. Kinematic wave approximation to the initiation of subsurface stormflow in a sloping forest soil. *Advanced Water Resources*. 9 (2): 70-76.

(Provided watersheds, facilities, and technical advice.)

Likens, Phyllis C., compiler. 1987. Addendum Hubbard Brook publication list. Millbrook, NY: Cary Arboretum. 23 p.

(The staff of Forest Service researchers involved with the Hubbard Brook Project provided input to this bibliography.)

Extramural

Bormann, F.H. 1986. Lessons from Hubbard Brook. In: Proceedings of the Chaparral ecosystems research meeting.; Santa Barbara, CA. Davis, CA: California Water Resource Center, University of California.: 7 p.

(Provided watershed, facilities, and technical advice.)

Bormann, F.H.; Likens, G.E. 1987. Changing perspectives on air-pollution stress. *BioScience*. 37 (6): 370.

(Provided watershed, facilities and technical advice.)

Bowden, W.B. 1986. Gaseous nitrogen emissions from undisturbed terrestrial ecosystems: an assessment of their impacts on local and global nitrogen budgets. *Biogeochemistry*. 2 (3): 249-279.

(Provided watersheds, facilities, and technical advice.)

Fuller, R.D.; Driscoll, C.T.; Lawrence, G.B.; Nodvin, S.C. 1987. Processes regulating sulphate flux after whole-tree harvesting. *Nature*. 325 (6106): 707-710.

(Provided watersheds, facilities, and technical advice.)

Fuller, R.D.; Driscoll, C.T.; Schindler, S.C.; Mitchell, M.J. 1986. A simulation model of sulfur transformations in forested Spodosols. *Biogeochemistry*. 2 (4): 313-328.

(Provided watersheds, facilities, and technical advice.)

Fuller, R.D.; Mitchell, M.J.; Krouse, H.R.; Wyskowski, B.J.; Driscoll, C.T. 1986. Stable sulfur isotope ratios as a tool for interpreting ecosystem sulfur dynamics. *Water, Air, and Soil Pollution*. 28 (1-2): 163-171.

(Provided watersheds, facilities, and technical advice.)

Galloway, James N.; Dianwu, Zhao; Jiling, Xiong; Likens, Gene E. 1987. Acid Rain: China, United States, and a remote area. *Science*. 236: 1559-1562.

(Provided watersheds, facilities, and technical advice.)

Glitzenstein, J.; Jones, C.; Kolasa, J.; Likens, G.; McDonnell, M.; and others. 1986. An essay on long-term ecological studies. *Bulletin of the Ecological Society of America*. 67 (4): 271-274.

(Provided watersheds, facilities, and technical advice.)

Hedin, L.O.; Likens, G.E.; Bormann, F.H. 1987. Decrease in precipitation acidity resulting from decreased SO₄ concentration. *Nature*. 325: 244-246.

(Provided watersheds, facilities, and technical advice.)

Holmes, R.T. 1986. Foraging patterns of forest birds: male-female differences. *Wilson Bulletin*. 98 (2): 196-213.

(Provided watershed, facilities and technical advice.)

Holmes, R.T.; Recher, H.F. 1986. Determinants of guild structure in forest bird communities: an intercontinental comparison. *Condor*. 88: 427-439.

(Provided watersheds, facilities, and technical advice.)

Holmes, R.T.; Sherry, T.W.; Sturges, F.W. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. *Ecological Monographs*. 56 (3): 201-220.

(Provided watersheds, facilities, and technical advice.)

Hooper, Richard P.; Shoemaker, Christine A. 1988. A comparison of chemical and isotopic hydrograph separation. *Water Resources Research*. 22 (10): 1444-1454.

(Provided watersheds, facilities, and technical advice.)

Nodvin, S.C.; Driscoll, C.T.; Likens, G.E. 1986. The effect of pH on sulfate adsorption by a forest soil. *Soil Science*. 142 (2): 69-75.

(Provided watersheds, facilities, and technical advice.)

Nodvin, Stephen C.; Driscoll, Charles T.; Likens, Gene E. 1986. Simple partitioning of anions and dissolved organic carbon in a forest soil. *Soil Science*. 142 (1): 27-35.

(Provided watersheds, facilities, and technical advice.)

Strayer, D.L. 1986. An essay on long-term ecological studies. *Bulletin of the Ecological Society of America*. 67 (4): 271-274.

(Provided watersheds, facilities, and technical advice.)

Attainment

For about 30 years continuous records have been kept of air and soil temperature, solar radiation, streamflow, and precipitation for 8 small watersheds at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire. This data has now been placed in a computerized database. Scientists, foresters, engineers, students, administrators, and others who often require long-term, high-quality data relating to meteorologic and hydrologic variables can easily access this data. A forest's health involves the inflow, outflow, and accumulation of nutrients in the system. Knowledge of the budget of such nutrients is important to understanding this health. Although great strides have been made to develop such budgets for natural forest ecosystems, some elements like nitrogen remain elusive, and for others their pathways are uncertain. A simplified system for determining these budgets quite accurately was established, starting with known volumes of soil, nutrients in the soil and a variety of plants, and inflow, outflow, and accumulations of water and nutrients in soil and plants in a natural setting. A 20-year or longer study is planned but measurements at 5-year intervals should provide trends. Such information should be valuable for developing long-range forest management plans for timber harvesting rotations, soil and water resources, and wildlife. An attempt was made to link on-the-ground ecological studies with remote sensing technology. Because of the vast ecological information and understanding of forest ecosystems generated at the HBEF, this forest was selected as one of 4 Biosphere Reserve sites to determine the feasibility of this linking. This approach looks promising for using ecological data coupled with remote sensing parameters for classifying regional or perhaps global systems and to discern possible long-term ecological changes.

Northeastern Forest Experiment Station
Forest Fire and Atmospheric Research
Research Work Unit 4451

SPRUCE-FIR RESEARCH COOPERATIVE
HERTEL, GERARD D., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. FOREST DAMAGE CAUSED BY ACID RAIN, ITS PRECURSORS AND ASSOCIATED POLLUTANTS	WMR	973	.5	1	1	
2. CAUSAL RELATIONSHIP BETWEEN ACID RAIN, ITS PRECURSORS AND ASSOCIATED POLLUTANTS.	WMR	3119	.5		2	

Problem 1**FOREST DAMAGE CAUSED BY ACID RAIN, ITS PRECURSORS
AND ASSOCIATED POLLUTANTS
FY 87 Research Attainments**

Publications**Research Unit**

Hertel, G.D.; Zarnoch, S.J.; Arre, T.; Eagar, C.; Mohnen, V.; Medlarz, S. 1987. Status of the Spruce - Fir Cooperative Research Program. In: The 80th Annual Meeting of The Air Pollution Control Association; 1987 June 21-26; New York, NY. 87-34.2. 19.

Extramural

Friedland, A.J.; Battles, J.J. 1987. Red Spruce (*Picea rubens* Sarg.) decline in the North-eastern United States: Review and recent data from Whiteface Mountain. In: Proceedings of the workshop on Forest Decline and Reproduction: Regional and Global Consequences; 1987 March 23-27; Krakow, Poland. IIASA. 287-296.

Attainment

Twenty-two research projects which were funded at the beginning of the Spruce - Fir Research Cooperative continued to provide data directed at determining the extent and magnitude of the decline of red spruce in the eastern U.S. Permanent vegetation plots were established at 5 high elevation intensive research sites along the Appalachian Mountains to evaluate and monitor forest condition. These plots provided the framework for evaluating soil chemical and physical properties and surveys of the incidence of damaging insects and pathogens. Other research cooperatives within the Forest Response Program provided atmospheric deposition, meteorological and remote sensing projects at these same sites. Other field projects were initiated to evaluate the relationship of the genetic make-up of red spruce to decline status. An intensive research site was established in Maine to study the effects of acid deposition on nutrient cycling in low elevation commercial red spruce forests. As of the end of FY 87, only preliminary data were reported for these projects through progress reports and workshops. Although preliminary, these data were provided to the Synthesis and Integration Project of the Forest Response Program for development of the Program's Major Program Outputs.

Problem 2**CAUSAL RELATIONSHIP BETWEEN ACID RAIN, ITS
PRECURSORS AND ASSOCIATED POLLUTANTS.
FY 87 Research Attainments**

Publications**Extramural**

Tseng, E.J. 1987. The impact of ozone, water stress and acid rain on the growth and physiology of Fraser fir seedlings. Blacksburg, VA: Virginia Polytechnic Institute and State University. 81. M.S. thesis.

Weinstein, L.H.; Kohut, R.J.; Jacobson, J.S. 1987. Research at Boyce Thompson Institute on the effects of ozone and acid precipitation on red spruce. In: The 80th Annual Meeting of The Air Pollution Control Association; 1987 June 21-26; New York, NY. 87-34.1. 20.

Attainment

Research directed at identifying the role of acid rain, its precursors and associated pollutants in the decline of red spruce is focused on two general mechanisms: 1.) indirect effects through soil mediated processes and 2.) direct effects through leaching of nutrients from the foliage, alterations in physiological processes resulting in changes in carbon allocation or increased winter damage. Twenty-two research projects have been funded over the past two years by the Spruce - Fir Research Cooperative to investigate these hypothesized mechanisms. These projects cover a broad range of experimental procedures from exposure to acid rain and/or ozone under highly controlled laboratory conditions to measurements of physiological processes, carbon allocation and growth at high elevation field sites known to be receiving differing levels of atmospheric inputs. Preliminary results from these projects have helped focus continued research into two areas: 1.) the impact of ozone on physiological processes (e.g., photosynthesis and respiration) and the winter hardiness of red spruce and 2.) acid deposition induced inhibition of nutrient uptake by roots. As of the end of FY 87, only preliminary data were reported for these projects through progress reports and workshops. Although preliminary, these data are being used by the Synthesis and Integration Project of the Forest Response Program for development of the program's Major Program Outputs.

Northeastern Forest Experiment Station
Forest Fire and Atmospheric Research
Research Work Unit 4452

EASTERN HARDWOODS RESEARCH COOPERATIVE
MCFADDEN, MAX W., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
51. EASTERN HARDWOODS RESEARCH COOPERATIVE	WMR	1622	1.0			

Problem 51**EASTERN HARDWOODS RESEARCH COOPERATIVE
FY 87 Research Attainments**

Publications

none

Attainment

The following investigators were funded through a competitive peer review process: Donald D. Davis and John M. Skelly (Penn State University), Imants Millers (USFS-FPM), John Witter (University of Michigan), Orie Loucks (Butler University), Keith F. Jensen (USFS, NEFES) and Elizabeth S. Groton (TVA).

During the fiscal year the Eastern Hardwoods Research Cooperative produced two reports: FY 1987 Research Plan and a Program Description.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4501

ECOLOGY AND MANAGEMENT OF NORTHEASTERN HARDWOOD INSECT
PESTS

WALLNER, WILLIAM E., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. NEED TO KNOW BIOLOGICAL SIGNIFICANCE OF FOREST SITES IN RELATION TO INITIATION OF OUTBREAKS	FIDR	279	1.7	2	1	1
2. NEED TO UNDERSTAND IMPACT OF NATURAL BIOLOGICAL CONTROL PROCESSES AT LOW DENSITIES	FIDR	158	1.0	1		2
3. COMPLETE DEVELOPMENT AND EVALUATE A COMPREHENSIVE PEST MANAGEMENT SYSTEM FOR GYPSY MOTH	FIDR	205	1.3	1		1

Problem 1

**NEED TO KNOW BIOLOGICAL SIGNIFICANCE OF FOREST SITES
IN RELATION TO INITIATION OF OUTBREAKS
FY 87 Research Attainments**

Publications

Research Unit

Meyer, G.A.; Montgomery, M.E. 1987. Relationships between leaf age and the food quality of cottonwood foliage for the gypsy moth, *Lymantria dispar*. *Oecologia*. 72: 527-532.

Wallner, W.E. 1987. Factors affecting insect population dynamics: Differences between outbreak and non-outbreak species. *Annual Review of Entomology*. 32: 317-340.

Cooperative

Anderson, D.E.; Miller, D.R.; Wallner, W.E.; Taigen, T.L.; Schwartz, J.J. 1987. A numerical simulation of the microclimate of gypsy moth caterpillars in forest canopies. In: 18th Conference, Agricultural and Forest Meteorology, and 8th Conference, Biometeorology and Aerobiology; 1987 September 15-18; West Lafayette, IN. Boston: American Meteorological Society: 353-355.

Extramural

Schultz, J.C.; Lechowicz, M.J. 1986. Hostplant, larval age, and feeding behavior influence midgut pH in the gypsy moth (*Lymantria dispar*). *Oecologia*. 71: 133-137.

Attainment

A review of world-wide literature ascertained that a concept of epicenters (foci) is used for several forest insects including the gypsy moth. Data gathered over a 5-year period found little difference in gypsy moth densities in susceptible sites, that may serve as foci for outbreaks, compared to resistant sites. However, the two forest types differed in survivorship of gypsy moth pupae which was related to differential impact of vertebrate predators. Differences in the suitability (i.e. food quality) of tree foliage have been examined and within tree differences such as between sun and shade leaves and between apical and basal leaves on a shoot impact considerably on gypsy moth food preferences. Foliage also affects the pH of caterpillar stomachs which in turn may influence susceptibility to virus infection. The effect of the physical environment provided by the forest was investigated by developing vertical profiles of the microclimate (global radiation, micrometeorology) for various canopy densities. These submodels were coupled with a submodel that calculates caterpillar temperature from an energy budget. Another model predicts caterpillar growth from body temperature. Thus, it is possible to numerically simulate microclimate in forest canopies and its effect on the gypsy moth. These data and models are part of a continuing effort to predict when and where gypsy moth may occur.

Problem 2

**NEED TO UNDERSTAND IMPACT OF NATURAL BIOLOGICAL
CONTROL PROCESSES AT LOW DENSITIES
FY 87 Research Attainments**

Publications

Research Unit

Smith, H.R. 1987. Understanding predation of gypsy moths (a little). Connecticut Land Trust Service Bureau. May: 2-3.

Cooperative

Cooper, R.J.; Dodge, K.M.; Martinat, P.J.; Smith, H.R.; Whitmore, R.C. 1987. Impacts of the gypsy moth on nongame bird populations. In: Coping with the gypsy moth in the new frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 48-58.

Stribling, H.L.; Smith, H.R. 1987. Effects of Dimilin on diversity and abundance of forest birds. Northern Journal of Applied Forestry. March; 4: 37-38.

Attainment

Predators (both vertebrate and invertebrate) have their major effect on gypsy moth when the population is at low density (latent phase). Some 50 species of birds and 20 species of mammals attack gypsy moth, but all are opportunistic which means that predation rate of gypsy moth is influenced by the availability, abundance and type of other alternative foods. Protective cover is also important; thin understory and shrub cover results in increased gypsy moth survival because white-footed mice forage less on the tree bole. Providing nest boxes for birds increases bird predation on forest caterpillars in Europe and is being evaluated here. Bird populations are also impacted by gypsy moth outbreaks; food supplies are first altered and then changes in habitat from tree mortality result in changes in the composition of the bird community. When low density gypsy moth populations in 1 ha plots were augmented with additional egg masses, parasitism of larvae increased in a density dependent manner and no increase in gypsy moth populations was observed. This phenomenon may explain the stability of gypsy moth in an area for several years between outbreaks. A parasitic wasp, *Glyptapanteles liparadis*, was imported from China and has been successfully colonized and is now available for release.

Problem 3**COMPLETE DEVELOPMENT AND EVALUATE A COMPREHENSIVE
PEST MANAGEMENT SYSTEM FOR GYPSY MOTH
FY 87 Research Attainments**

Publications**Research Unit**

Wallner, W.E. 1987. Susceptible forest sites: their perceived role in gypsy moth population dynamics. In: 1986 Gypsy Moth Review; 1986 December 4-6; Norfolk, VA. Richmond, VA: Virginia Department of Agriculture: 175-176.

Cooperative

Casagrande, R.A.; Logan, P.A.; Wallner, W.E. 1987. Phenological model for gypsy moth, *Lymantria dispar* (Lepidoptera: Lymantriidae), larvae and pupae. Environmental Entomology. 16: 556-562.

Attainment

Evaluation of the suppression of natural, endemic populations by overflooding with F1-sterile gypsy moth eggs was continued in Vermont and past trials were monitored in Maryland and West Virginia. Plots ranging from 1 to 57 ha that initially had from 2.4 to 91.2 egg masses/acre were overflooded with 15 to 40 times sterile egg masses. These populations were reduced or remained at low levels even though surrounding populations may have increased. However, the effect on the native population was not due to genetic manipulation (cross-mating with F1-steriles) but to increased parasitism. The increase in host density via application of the F1-sterile eggs apparently attracted parasites to the treatment areas; percent parasitism, particularly by the polyphagous tachinid, *Compsilura concinnata*, was dramatically higher. The insecticide, diflubenzuron, was not found to directly endanger birds nor did the reduction of invertebrate food items appear to cause significant decreases in bird populations. Caterpillar food preferences for foliage changed with leaf development from lower to upper canopy; since the target organism remains mostly in the lower canopy until full leaf expansion, aerial applications delayed beyond 50 percent leaf expansion may not reach their full target.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4502

**PATHOLOGY AND MICROBIAL CONTROL OF INSECTS DEFOLIATING
EASTERN FOREST TREES**

MCMANUS, MICHAEL L., Project Leader

**FY 87 Research Attainments
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. IMPROVE INSECT PATHOGENS AND DEVELOP AND IMPROVE FORMULA- TION/APPLICATION TECHNOLOGY	FIDR	305	1.9	2	1	
2. FORECASTING NATURALLY OCCURRING VIRUS EPIZOOTICS REQUIRES UNDERSTANDING NPV EPIZOOTIOLOGY	FIDR	120	1.5	2	1	1
3. NEED TO DEVELOP AND EVALUATE INTEGRATED PEST MANAGEMENT STRATEGIES TO MANAGE THE GYPSY MOTH	FIDR	185	.6	2	2	3

Problem 2

**FORECASTING NATURALLY OCCURRING VIRUS EPIZOOTICS
REQUIRES UNDERSTANDING NPV EPIZOOTIOLOGY
FY 87 Research Attainments**

Publications

Research Unit

Mazzone, H.M. 1987. Chromosome banding in cultured cells transformed by polyoma virus. In: Proceedings of the 45th annual meeting of the Electron Microscopy Society of America.; August 3-7, 1987; Baltimore, Maryland. San Francisco, California: San Francisco Press: 950-951.

Podgwaite, John D. 1987. Gypsy moth nucleopolyhedrosis virus: Patterns for survival. In: Program, Society of Invertebrate Pathology. 20th annual meeting.; July 20-24, 1987.; Gainesville, Florida. Gainesville, Florida: University of Florida Press: 42-44.

Cooperative

Wood, H.A.; Burand, J.P.; Hughes, P.R.; (and others). 1986. Transovarial transmissions of *Lymantria dispar* nuclear polyhedrosis virus. In: Fundamental and applied aspects of invertebrate pathology.; August 18-22, 1986.; Veldhoven, The Netherlands. Wageningen, The Netherlands: Foundation of the Fourth International Colloquium of Invertebrate Pathology.: 405.

Extramural

Woods, S.A.; Elkinton, J.S. 1987. Bimodal patterns of mortality from nuclear polyhedrosis virus in gypsy moth (*Lymantria dispar*) populations. *Journal of Invertebrate Pathology*. (50): 151-157.

Attainment

Cooperators at UMASS assisted in identifying the major factors that influence GM NPV epizootiology and ultimately cause population collapse. A bimodal pattern of virus mortality which occurs in GM populations can be detected from bioassays of virus-contaminated foliage and by rearing larvae from egg masses collected pre-season. The virus is transmitted between generations through contamination of eggs from environmental surfaces during or within a few days of their oviposition. These studies also determined that burlap-banding, a commonly-used tool to monitor GM larval populations, can be used to accurately estimate the level of virus-related mortality in populations. Cooperative research at Boyce Thompson Institute (BTI) has demonstrated that the GM moth virus is transmitted transovarially through the egg stage but at very low levels. Significant progress has also been achieved toward identifying chemical and environmental stresses that may induce productive (lethal) virus replication in persistently infected larvae and cell cultures. For the GM virus to infect healthy larvae, it must penetrate the peritrophic membrane, a protective sheath that protects the larva's mid-gut cells. A coop study with BTI has defined the ultrastructure and composition of this membrane in GM larvae and determined that midgut digestive fluids contain a heat-labile factor that inactivates the virus. After characterizing this factor, scientists can select adjuvants which, when added to viral formulations, will negate its effect and enhance viral infection. Four new GM moth cell lines have been developed by ARS cooperators at Beltsville, and are being jointly evaluated as to their ability to support virus production and replication. One cell line the first ever fat-body cell line developed for the GM looks especially promising for supporting virus replication.

Problem 3

NEED TO DEVELOP AND EVALUATE INTEGRATED PEST MANAGEMENT STRATEGIES TO MANAGE THE GYPSY MOTH

FY 87 Research Attainments

Publications

Research Unit

Mazzone, H.M.; Douglas, S.M. 1986. Studies on natural silks of insects. In: Proceedings of the 44th annual meeting of the Electron Microscopy Society of America.; August 11-15 1986.; Albuquerque, N.M. San Francisco, CA: San Francisco Press: 950-951.

McManus, M.L. 1987. The gypsy moth problem: History, biology, spread. In: Coping with the gypsy moth in the new frontier: Proceedings of a workshop for forest managers.; August 4-6 1987; Morgantown, W.VA. Morgantown, W.VA: West Virginia University Books: 1-10.

Cooperative

Reardon, R.; McManus, M.; Kolodny-Hirsch D.; (and others). 1987. Development and implementation of a gypsy moth integrated pest management program. Journal of Aboriculture. 13 (9): 209-216.

Reardon, R. C.; McManus, M.L.; Kolodny-Hirsch, D. 1987. Maryland Gypsy Moth IPM Pilot Project. In: Proceedings 1986 Gypsy Moth Annual Review; December 1-4 1986; Norfolk, VA. Richmond, VA: Virginia Cooperative Extension Service: 99-105.

Reardon, R.C.; Kolodny-Hirsch, D.M.; McManus, M.L. 1987. Gypsy moth integrated pest management. In: Proceedings, integrated pest management symposium for northern forests; March 24-27 1986; Madison, Wisconsin. Madison, Wisconsin: University of Wisconsin Cooperative Extension Service.: 203-215.

Extramural

Elkinton, J.S. 1987. Changes in efficiency of the pheromone-baited milk-carton trap as it fills with male gypsy moths (Lepidoptera: Lymantriidae). Journal of Economic Entomology. 80: 754-757.

Jeffords, M. R.; Maddox, J.V.; O'Hayer, K.W. 1987. Microsporidian spores in gypsy moth larval silk: A possible route of horizontal transmission. Journal of Invertebrate Pathology. 49: 332-333.

Attainment

Continuing research on exotic microsporidia, important pathogens of the GM in Europe, indicates that these organisms could be an important addition to the natural enemy complex of GM in the U.S. Results from 1986-87 introductions via artificially contaminated egg masses of several species of microsporidia conducted cooperatively with scientists from the Ill. Nat. History Survey, suggest that 10-20 percent of the field collected larvae sampled were infected and that at least one species of *Nosema* was successfully transmitted to the next generation through egg masses produced by infected female moths. Cooperators at VPI are developing models that can be used to relate pheromone trap catches and morphometrics of captured males, to population quality and densities of other life stages. Preliminary results from data collected 1985-86, indicate there is a good correlation ($r^2=.80$) between male wing length and eggs per mass, and wing length and egg masses per unit area at the plot level. Results also suggest that lipid content of male moths is positively correlated to wing length and population density. Cooperators at UMASS are developing a system based on pheromone traps to monitor GM populations over a broad geographic area. Three different strategies were tested with the objective being to reduce male catch in the standard trap, while still relating trap capture to actual population density: (1) reduce the rate of pheromone release; (2) make the trap difficult for males to enter; (3) use racemic rather than (plus) disparlure as the source pheromone. The reduced-rate lures did not reduce capture because the rates of release requested were not in fact achieved. The modified trap (2) effected a 100 x reduction in capture, while the racemic trap (3) caused a 3 x reduction. Based on initial results, the modified trap may be a good candidate for future use.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4503

EFFECTS OF ATMOSPHERIC DEPOSITION ON FORESTS AND TREES IN THE
EASTERN UNITED STATES

JENSEN, KEITH F., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. EFFECTS OF ATMOSPHERIC DEPOSITION ON BIOCHEMI- CAL/PHYSIOLOGICAL PROCESSES	FIDR	324	3.2	1		4
2. EFFECTS OF AIR POLLUTION AND ACID DEPOSITION ON FOREST GROWTH STAGES AND PROCESSES	FIDR	673	4.7	5		1
M1. ASSOCIATED RESEARCH PUBLICATIONS	FIDR	0	.0	5		1

Problem 1

**EFFECTS OF ATMOSPHERIC DEPOSITION ON
BIOCHEMICAL/PHYSIOLOGICAL PROCESSES
FY 87 Research Attainments**

Publications

Research Unit

McQuattie, Carolyn J.; Rhodes, Landon H. 1984. Effect of simulated acid rain on endomycorrhizal development and growth of black locust in two soils. *Phytopathology* 74(10): 1270.

Cooperative

Boyer, J.M.; Houston, D.B.; Jensen, K.F. 1986. Impacts of chronic SO₂, O₃ and SO₂ + O₃ exposures on photosynthesis of *Pinus strobus* clones. *European Journal of Forest Pathology*. 16: 293-299.

Crang, Richard E.; McQuattie, Carolyn J. 1987. A quantitative light microscopic technique to assess the impact of air pollutants on foliar structure. *Transactions American Microscopy Society*. 106 (2): 164-172.

Roberts, B.R.; Dochinger, L.S.; Townsend, A.M. 1986. Effects of atmospheric deposition on sulfur and nitrogen content of four urban tree species. *Journal of Arboriculture*. 12 (9): 209-212.

Wong, B.L.; Melhuish, J.H.; McQuattie, C.J. 1987. The effect and distribution of Al in mycorrhizal and non-mycorrhizal loblolly pine seedlings. *Mycological Society of America Newsletter*. 38 (1): 56.

Attainment

Atmospheric deposition (AD) is a unique stress factor. At ambient concentrations it seldom causes injury that is visible to the naked eye. However, AD may be causing injury at the cellular level. Both acid mist and gaseous pollutants affect the total mesophyll area (TMA) of leaves. TMA of yellow poplar seedlings leaves significantly decreased as the acidity of mist increased from pH 3.6 to 2.6. When seedlings were treated with acidic mist and then fumigated with N₂O, the TMA of the leaves increased as the acidity increased from pH 5.6 to 3.6, but decreased as the acidity was increased to pH 2.6. The relationship between TMA and seedling growth is not completely understood, but as the mesophyll area decreases the amount of carbohydrate produced may also decrease. The result may be a smaller or less vigorous plant. The increase in TMA with N₂O treatment may be due to the stimulating effect of nitrogen and demonstrate the difficulty in studying plant response to stress. The initial plant response to stress may be hard to define and then the response may be further modified either synergistically or antagonistically by other stress factors. AD will also influence mycorrhizae development. On seedlings grown in nutrient solution with different pH's and lead concentrations, no significant differences were detected in the growth characteristics but the mycorrhizae hyphal mantle was affected. As the hyphal mantle is important in nutrient absorption a reduction of this tissue may result in a decrease in the amount of nutrients absorbed. Thus, AD may affect the growth of seedlings in many ways without the development of visual symptoms. It is only through a complete understanding of the cellular response to AD will the impact of AD on current and future tree growth be determined.

Problem 2

**EFFECTS OF AIR POLLUTION AND ACID DEPOSITION ON
FOREST GROWTH STAGES AND PROCESSES
FY 87 Research Attainments**

Publications

Research Unit

Barger, Jack H.; Cannon, William N., Jr. 1987. Effects of ozone and acid rain on pesticide degradation, Delaware, County, OH, 1986. Insecticide and Acaricide Tests. 12: 354.

Dochinger, L. S. 1986. Environmental studies on air-pollution-induced growth responses of eastern deciduous trees. In: Developing procedures for evaluation of visible air pollution effects in broad-leaved species. Problem definition, protocol, and research needs. Muir, P.S.; Armentano, T.V.; 1985 April 3-4; Indianapolis, IN. Indianapolis, IN: Holcomb Research Institute, Butler University: 12.

Jensen, Keith F. 1987. Effect of simulated acid rain and ozone on growth of red and white oak seedlings. In: Perry, R.; Harrison, R.M.; Bell, J.N.B.; Lester, J.N., comps., eds. Acid Rain: Scientific and Technical Advances. London: Selper Ltd: 576-579.

Jensen, Keith F. 1987. Effect of simulated acid rain and ozone on growth of red and white oak seedlings. Botanical Society of America Proceedings. 696.

Schier, George A. 1987. Throughfall chemistry in a red maple provenance plantation sprayed with "acid rain". Canadian Journal of Forest Research. 17: 660-665.

Cooperative

Hall, Richard W.; Barger, Jack H. 1987. Effects of atmospheric deposition on efficacy of pesticides for elm leaf beetle control, Delaware, County, OH, 1985. Insecticide and Acaricide Tests. 12: 350-351.

Attainment

Forest decline has been observed in the eastern United States and in western Europe in the last decade. The cause of this widespread phenomenon is unknown, but numerous observations and studies have implicated atmospheric deposition (AD) as one of the possible causes. In studies on the effect of simulated acid rain (SAR) and ozone (O₃) on oak and yellow poplar seedlings conflicting results were found. The pollutants had little or no effect on oak seedlings after 18 weeks of treatment, whereas growth of the yellow poplar seedlings decreased with an increase in the O₃ concentration and in the acidity of the SAR. This apparent conflict is due in part to the growth habit of the different species. While the yellow poplar seedlings grew throughout the 18-week exposure period the oak seedlings set bud after about 5 weeks. The seedlings may also have been adversely affected in another manner. The effect may have been on starch production with less reserves being available for growth the following year. This type of effect can only be determined in studies running 2 years or more. The hypothesis that acid precipitation is harmful to trees because it leaches mineral elements from the foliage was tested by spraying SAR red maple trees. The throughfall were collected and the pH and mineral content measured. The pH of the SAR increased during throughfall. Ca, K, Mg, Fe, Na, Zn, and B were detected in the throughfall and the elemental concentrations increased with increased acidity of the SAR. Research data from these studies are being used to evaluate the hypotheses that AD is an important causal factor in forest decline.

Problem M1

ASSOCIATED RESEARCH PUBLICATIONS
FY 87 Research Attainments

Publications

Research Unit

Barger, Jack H.; Cannon, William N., Jr. 1987. Response of smaller European elm bark beetle to pruning wounds on American elm. *Journal of Arboriculture*. 13 (4): 102-104.

Cannon, William N., Jr. 1986. Effects of female size in relation to adult density on development of *Scolytus multistriatus* populations. In: *Proceedings 41st Annual Meeting, North Central Branch, Entomological Society of America*; 1986 March 24-17; Minneapolis, MN. Lincoln, NE: North Central Branch, Entomological Society. Abstract.

Jensen, K.F.; Yaussy, D. 1986. Comparison of yellow-poplar growth models on the basis of derived growth analysis. *Tree Physiology*. 1: 217-222.

Krause, C.R.; Ichida, J.M.; Dochinger, L.S. 1986. Osmium vapor pretreatment of *Gnomia* infected leaves. *Scanning Electron Microscopy*. III: 975-978.

Schier, George A. 1988. Aspen Reproduction. In: *Proceedings of the Society of American Foresters 1985 Convention*; 1985 July 28-31; Ft. Collins, CO. Bethesda, MD: Society of American Foresters: 92-95.

Cooperative

Schroeder, Herbert W.; Buhoff, Gregory J.; Cannon, William N., Jr. 1986. Cross-validation of predictive models for esthetic quality of residential streets. *Journal of Environmental Management*. 23: 309-316.

Attainment

Problem M1 includes publications not covered by Problem Areas 1 and 2.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4505

ETIOLOGY, EPIDEMIOLOGY AND PHYSIOLOGY OF STRESS-REGULATED
HOST-PEST INTERACTIONS (STRESS-TRIGGERED TREE DISEASES)
HOUSTON, DAVID R., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. HOW BIOTIC AND ABIOTIC STRESSES REGULATE THE ECOLOGICAL AND PHYSIOLOGICAL INTERACTIONS	FIDR	176	.7	2		4
2. DOES ATMOSPHERIC DEPOSITION PREDISPOSE TREES TO ATTACK BY DISEASE AND INSECT PESTS?	FIDR	299	.6	6		
3. BIOCONTROL APPROACHES TO MANAGING STRESS-REGULATED DISEASE	FIDR	68	.7	1		
4. DEVELOPING PROCEDURES TO ESTIMATE THE EFFECTS OF STRESS-REGULATED PEST-HOST INTERACTIONS.	FIDR	71	1.0	1		2

Problem 1 **HOW BIOTIC AND ABIOTIC STRESSES REGULATE THE
ECOLOGICAL AND PHYSIOLOGICAL INTERACTIONS
FY 87 Research Attainments**

Publications

- Research Unit** Houston, D.R. 1986. Insects and diseases of northern hardwood ecosystems. In: A conference on the northern hardwood resource: Management and potential; 1986 August 18-20; Houghton, MI. Houghton, MI: Michigan Technological University: 109-138.
- Houston, D.R. 1986. Recognizing and managing diebacks/declines. In: Integrated pest management symposium for northern forests; 1986 March 24-27; Madison, WI. Madison, WI: University of Wisconsin-Extension: 153-166.
- Cooperative** Burns, B.S.; Houston, D.R. 1987. Managing beech bark disease: Evaluating defects and reducing losses. Northern Journal of Applied Forestry. 4: 28-33.
- Mielke, M.E.; Houston, D.R.; Bullard, A.T. 1986. Beech bark disease management alternatives. In: Integrated pest management symposium for northern forests; 1986 March 24-27; Madison, WI. Madison, WI: University of Wisconsin-Extension: 272-280.
- Nebeker, T.E.; Houston, D.R.; Hodges, J.D. 1987. Forest pests: Influence of forest management practices on pest population dynamics and forest productivity. In: Physiology Working Group Technical Session, Society of American Foresters National Convention; 1985 July 28-31; Fort Collins, CO. Martinus Nijhoff Publishers: 101-112.
- Williams, R.E.; Shaw, C.G. III; Wargo, P.M.; Sites, W.H. 1987. Armillaria root disease. In: Forest Insect & Disease Leaflet. 78. Washington, DC: U.S. Department of Agriculture, Forest Service: 8 p.

Attainment

Beech bark disease (BBD): *Nectria coccinea* var. *faginata* (NCF) and *N. galligena* (NG) infect and kill bark infested with beech scale. We found NG most common in W. Va. and western Pa.; NCF in NY, New England and Canada. In 1986, *N. ochroleuca* (NOL) alone or with NG was found in Pa., W. Va., and Ontario. NOL was less pathogenic than NG or NCF inoculated into logs from scale-free trees. If NOL can attack scale-infested bark, it will show that pathogens can be "created" when host defenses are rendered ineffective by new stress factors. Analyses of bark indicate that susceptible trees have higher spring amino acid concentrations (individual and total) than trees resistant to scale. AA concentrations may be indicators of susceptibility.

Oak decline: Evaluation of *Armillaria* from pockets of mortality in defoliated oak stands indicates that most isolates belong to Bio. Species VII (compatible with European sp. *A. bulbosa*, a stress induced pathogen). Clones, determined by in-vitro pairing, are numerous within the stands and occupy fairly small areas.

Sapstreak: A trial began in 1985 to see if trees stressed by defoliation are more vulnerable to *C. coerulea*. Twenty trees were inoculated just before (1985) and 20 a year after (1986) defoliation. So far, 10 trees have died of which 7 were inoculated in 1985. So far, non-defoliated trees are as vulnerable as defoliated ones.

Problem 2

**DOES ATMOSPHERIC DEPOSITION PREDISPOSE TREES TO
ATTACK BY DISEASE AND INSECT PESTS?
FY 87 Research Attainments**

Publications

Research Unit

Houston, D.R. 1987. Beech bark disease. In: Skelly, J.M.; Davis, D.D.; Merrill, W.; Cameron, E.A., comps., eds. Diagnosing injury to eastern forest trees. A manual for identifying damage caused by air pollution, pathogens, insects and abiotic stresses. University Park, PA: Penn State University, NAPAP, Forest Responses Program, Vegetation Research Cooperative; 29-30.

Houston, D.R. 1987. Diebacks and declines. In: Skelly, J.M.; Davis, D.D.; Merrill, W.; Cameron, E.A., comps., eds. Diagnosing injury to eastern forest trees. A manual for identifying damage caused by air pollution, pathogens, insects and abiotic stresses. University Park, PA: Penn State University, NAPAP, Forest Responses Program, Vegetation Research Cooperative; 23-25.

Houston, D.R. 1987. Sapstreak disease of sugar maple. In: Skelly, J.M.; Davis, D.D.; Merrill, W.; Cameron, E.A., comps., eds. Diagnosing injury to eastern forest trees. A manual for identifying damage caused by air pollution, pathogens, insects and abiotic stresses. University Park, PA: Penn State University, NAPAP, Forest Responses Program, Vegetation Research Cooperative; 27-29.

Wargo, P.M. 1987. Maple decline. In: Skelly, J.M.; Davis, D.D.; Merrill, W.; Cameron, E.A., comps., eds. Diagnosing injury to eastern forest trees. A manual for identifying damage caused by air pollution, pathogens, insects and abiotic stresses. University Park, PA: Penn State University, NAPAP, Forest Responses Program, Vegetation Research Cooperative; 25-27.

Wargo, P.M. 1987. Oak declines. In: Skelly, J.M.; Davis, D.D.; Merrill, W.; Cameron, E.A., comps., eds. Diagnosing injury to eastern forest trees. A manual for identifying damage caused by air pollution, pathogens, insects and abiotic stresses. University Park, PA: Penn State University, NAPAP, Forest Responses Program, Vegetative Research Cooperative; 31-35.

Wargo, P.M.; Carey, A.C.; Geballe, G.T.; Smith, W.H. 1987. Occurrence of rhizomorphs of *Armillaria* in soils from declining red spruce stands in three forest types. *Plant Disease*. 71: 163-167.

Attainment

Evaluation of the crown and root system of healthy (asymptomatic) and initial decline red spruce, *Picea rubens*, showed that declining trees had greater numbers of (1) branches with brooms, (2) brooms per branch, and (3) dead branch tips, fewer living tips, less internode growth and weight, fewer needles and less needle weight per internode for at least 5 years. Declining trees had greater amounts of dead 2nd thru 5th order woody roots and fewer living nonwoody roots. The types of mycorrhizae on nonwoody root tips were significantly fewer on declining trees. Regression analyses indicate that several root variables are "transitional" and may indicate changes in tree health. Research on effects of soil cations on growth of root disease fungi showed that *Armillaria* (AM) spp, *Perenniporia subacida* (PS) and *Scytinostroma galactinum* (SG) were significantly inhibited by Al. Degree of inhibition differed for each fungus and depended on the conc. of Al and pH of the media. In general, inhibition was greater at pH 3.5 than at pH 4.5. AM was most sensitive to Al. Rhizomorph production ceased after 100 ppm at pH 4.5 and was completely inhibited by all Al levels at pH 3.5. Radial growth ceased at 400 ppm at both pH's. SG was more sensitive than PS to Al but each produced some radial growth at 500 ppm at pH 4.5; neither grew at 500 ppm at pH 3.5. Results suggest that increased Al conc. resulting from increased soil acidification can affect the ecology of these pathogens.

Problem 3

**BIOCONTROL APPROACHES TO MANAGING
STRESS-REGULATED DISEASE
FY 87 Research Attainments**

Publications

Research Unit

Houston, David R.; Houston, Daniel B. 1987. Resistance in American beech to *Cryptococcus fagisuga*: Preliminary findings and their implications for forest management. In: 30th Northeastern Forest Tree Improvement Conference; 1986 July 22-24; Orono, ME. Orono, ME: University of Maine, School of Forest Resources: 105-116.

Attainment

Beech bark disease presents a difficult and perplexing management problem, first, when massive mortality of large, old trees occurs quickly; later, as dense stands of young, small trees are gradually rendered highly defective. Resistance to the disease exists and, if explorable, offers the best option for control. We have found that resistant trees occur in many forests, are easily recognized in long-affected stands, and often occur in groups that genetically are closely related. A 3-year study was begun in 1986 to characterize the level (numbers), distribution patterns, genetic relationships and age/growth relationships of all resistant trees in eight stands in Canada (4) and Maine (4). The objective of this study is to help clarify patterns of susceptibility and vulnerability to insects and diseases and to track the flow of genes for these traits through populations over time. Such knowledge will provide the basis for silvicultural practices to reduce losses to insects and diseases.

Armillaria root disease: Rhizomorph production from a woody substrate was significantly inhibited in a peat, sand, and perlite mixture by EDTA and NaEDTA at 800 ppm (wt/wt). Rhizomorph production at 3200 ppm was 85 percent of that in the control. Effectiveness of EDTA as a rhizomorph inhibitor in natural soils will be explored.

Problem 4 **DEVELOPING PROCEDURES TO ESTIMATE THE EFFECTS OF
STRESS-REGULATED PEST-HOST INTERACTIONS.
FY 87 Research Attainments**

Publications

Research Unit Valentine, H.T.; Gregoire, T.G.; Furnival, G.M. 1987. Unbiased estimation of total tree weight by three-stage sampling with probability proportional to size. In: Estimating tree biomass regressions and their error. Proceedings of the workshop on tree biomass regression functions and their contribution to the error of forest inventory; 1986 May 26-30; Syracuse, NY. Gen. Tech. Rep. NE-GTR-117. Broomall, PA: U.S. Department of Agriculture, Forest Service: 129-132.

Cooperative Furnival, G.M.; Valentine, H.T.; Gregoire, T.G. 1986. Estimation of log volume by importance sampling. Forest Science. 32 (4): 1037-1078.

Gregoire, T.G.; Valentine, H.T.; Furnival, G.M. 1986. Importance sampling in forest inventory. In: Forests, the World and the Profession; 1986 October 5-8; Birmingham, AL. Bethesda, MD: Society of American Foresters: 70-73.

Attainment

Spruce Decline: A carbon-balance model of stand growth was derived in cooperation with the Acid Rain project of the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. The specific rates of assimilate production and feeder root turnover are explicitly isolated in the model because these rates are hypothesized to be directly affected by air pollution/acid rain leading to reduced growth and, possibly, decline syndrome. The model has a unique framework based on the pipe-model theory which affords realistic dry matter partitioning corresponding to apical or cambial growth. This new modeling theory and methodology has been presented at international meetings and in a IIASA report.

General: Probability sampling methods were developed which furnish unbiased estimates of volume, biomass, or increment of individual trees or of all trees on a research or inventory plot. These methods are preferable to conventional regression estimators which give biased estimates if insects, disease, or acid rain cause alterations in the growth characteristics of trees.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4506

**BIOLOGY AND MANAGEMENT OF INSECTS AFFECTING OAK
REGENERATION**

PEACOCK, JOHN W., Project Leader

**FY 87 Research Attainments
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. IDENTITY, BIOLOGY AND CHARACTER OF DAMAGED CAUSED BY MAJOR PESTS OF UPLAND OAK REGENERATION	FIDR	126	1.5	3		
2. PREVENT OR REDUCE DAMAGE BY INSECTS THAT AFFECT UPLAND OAK REGENERATION.	FIDR	125	1.5	2		

Problem 1

**IDENTITY, BIOLOGY AND CHARACTER OF DAMAGED CAUSED
BY MAJOR PESTS OF UPLAND OAK REGENERATION
FY 87 Research Attainments**

Publications

Research Unit

Galford, Jimmy R.; Wright, Susan L.; Peacock, John W. 1987. Entomologists look at oak regeneration. Ohio Woodlands. Summer: 12-13.

Galford, Jimmy R. 1987. Effect of *Stelidota octomaculata* (Coleoptera:Nitidulidae) on germinating acorns under laboratory conditions. In: Proceedings of the 6th central hardwood forest conference.; 1987 February 24-26.; Knoxville, TN. Knoxville, TN: University of Tennessee: 419-422.

Galford, Jimmy R. 1987. Feeding habits of the weevil *Barypeithes pellucidus* (Coleoptera:Curculionidae). Entomological News. 98 (4): 163-164.

Attainment

The sap beetle, *Stelidota octomaculata*, destroys sound germinating acorns of red and white oak. Adult beetles consume the tender radicle, and can feed on the tips of developing shoots. In the field, mass attacks by this beetle are common, and acorns are apparently the major host in the spring. Feeding activity by *S. octomaculata* undoubtedly affects acorn germination and subsequent seedling establishment.

It has been determined that a weevil, *Barypeithes pellucidus*, will feed on at least 18 plant species in central Ohio. Northern red oak, American elm, hawthorn and black cherry are preferred hosts. Adult weevils consume leaves and small stems on new growth, chiefly on small plants (2-30 cm high). Larvae may be root feeders; larvae have been reared through 3 instars on red oak roots in the laboratory.

S. octomaculata and *B. pellucidus* are the latest pest insects to be added to the list of those that damage or destroy oak acorns and small seedlings. Singly or in concert, these insects destroy millions of acorns/seedlings each year in mature oak stands. Clearly, insects are a significant factor in limiting acorn germination and oak seedling establishment.

Problem 2**PREVENT OR REDUCE DAMAGE BY INSECTS THAT AFFECT
UPLAND OAK REGENERATION.
FY 87 Research Attainments**

Publications**Research Unit**

Wright, Susan L. 1986. Prescribed burning as a technique to manage insect pests of oak regeneration. In: Proceedings of prescribed burning in the Midwest: State of the art; 1986 March 4-5; Stevens Point, WI. Stevens Point, WI: University of Wisconsin: 91-96.

Wright, Susan L. 1987. Managing insects affecting oak regeneration by prescribed burning. In: Current topics in forest research: Emphasis on contributions by women scientists: Proceedings of a national symposium; 1986 November 4-6; Gainesville, FL. Gen. Tech. Rep. SE-46. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 186-192.

Attainment

Between the fall of 1985 and the spring of 1987, 4800 red oak and 4800 white oak acorns were planted in 80 plots in the understory of mature oak stands in southern Ohio. Half of the plots were sprayed with insecticide biweekly each year during the growing season; the remaining plots were unsprayed. All seedlings in all plots were checked biweekly and determinations were made of insect feeding and damage, and growth and survival of seedlings. It is premature at this time to draw conclusions concerning insect damage and seedling growth and survival in sprayed and unsprayed plots. However, preliminary evaluations indicate that, at least for red oaks, acorn germination and seedling survival is greater in sprayed plots. Continuation of this study for at least an additional two years will allow us to determine if a reduction in insect damage (resulting from insecticide treatment of acorns/seedlings) will result in increased oak seedling survival. This information is critical in efforts to ascertain the significance of insects in the oak regeneration

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4507

SILVICULTURAL OPTIONS FOR THE GYPSY MOTH
MASON, GARLAND N., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. EFFECTS OF DAMAGE BY THE GYPSY MOTH AND ITS ASSOCIATED ORGANISMS IN VARIOUS TYPES OF FOREST	FIDR	432	.6	3	2	
2. SILVICULTURE PRACTICES IN REDUC. DAMAGE TO FOREST STANDS BY THE GYPSY MOTH AND ASSOCIATED ORGANISMS	FIDR	510	1.0	4	1	2
3. DEVELOP AND EVALUATE INTEGRATED PEST MANAGEMENT STRATEGIES TO MANAGE THE GYPSY MOTH	TMR	283	1.0	2	1	

Problem 1**EFFECTS OF DAMAGE BY THE GYPSY MOTH AND ITS
ASSOCIATED ORGANISMS IN VARIOUS TYPES OF FOREST
FY 87 Research Attainments****Publications****Research Unit**

Gottschalk, Kurt W. 1986. Impacts of gypsy moth defoliation on regeneration of forest stands: A summary. In: 1986 Gypsy moth annual review; 1986 December 1-4; Norfolk, VA. Richmond, VA: Virginia Cooperative Extension Service: 179-181.

Mason, Garland N. 1987. Rating stand susceptibility to gypsy moth defoliation. In: Proceedings, Coping with the gypsy moth in the new frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 65-72.

Mason, Garland N.; Gottschalk, Kurt W. 1986. Hazard rating for gypsy moth. In: 1986 Gypsy moth annual review; 1986 December 1-4; Norfolk, VA. Richmond, VA: Virginia Cooperative Extension Service: 200-210.

Extramural

Hicks, Ray R.; Fosbroke, David E. 1987. Mortality following gypsy moth defoliation in the central Appalachians. In: Hay, Ronald; Woods, Frank W.; DeSelm, Hal. Proceedings, 1987 Central hardwood forest conference VI; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 423-426.

Hicks, Ray R.; Fosbroke, David E. 1987. Stand vulnerability: Can gypsy moth damage be predicted?. In: Proceedings, Coping with the gypsy moth in the new frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 73-80.

Attainment

Five publications have addressed Problem Area 1. Two of these papers reviewed techniques available to forest managers to hazard rate forest stands. Two papers provide guidelines on predicting mortality within forest stands while the final paper provides significant insight into the effects of gypsy moth on regenerating new stands. These accomplishments directly relate to Problem 1 and provide a good basis on which to refine available management guidelines. These findings were presented at user and regional meetings through presentations. Presently, guidelines and hazard rating systems are being implemented by the W.V. Department of Forestry, PA Bureau of Forestry, MD Division of Forestry, Parks and Wildlife, Ohio Division of Forestry, the WESTVACO Pulp and Paper Co., and the National Forest System. A study of shoestring root rot was completed in Maryland. Data has been analyzed and information on the abundance and distribution of *Armillaria mellea* rhizomorphs on these effects relating to dead or declining trees since time of death, will be published sometime next year. Defoliation and mortality data were collected on the 225 risk-rating plots again in 1987 for the 10th consecutive year with the cooperation of International Paper Co., Pennsylvania Bureau of Forestry, Glatfelter Paper Co., VPI, and NA FPM.

Problem 2

**SILVICULTURE PRACTICES IN REDUC. DAMAGE TO FOREST STANDS BY THE GYPSY MOTH AND ASSOCIATED ORGANISMS
FY 87 Research Attainments**

Publications

Research Unit

Gottschalk, Kurt W. 1987. Prevention: The silvicultural alternative. In: Proceedings, Coping with the gypsy moth in the new frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 92-104.

Gottschalk, Kurt W. 1987. Silvicultural guidelines for forest stands threatened by the gypsy moth: A summary. In: Proceedings, 4th annual biennial southern silvicultural conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 345-346.

Gottschalk, Kurt W. 1987. Silvicultural guidelines for forest stands threatened by the gypsy moth: A summary. In: Hay, Ronald; Woods, Frank W.; DeSelm, Hal. Proceedings, 1987 Central hardwood forest conference VI; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 509-510.

Gottschalk, Kurt W. 1987. Silvicultural guidelines for stands threatened by the gypsy moth: A summary. In: 1986 Gypsy moth annual review; 1986 December 1-4; Norfolk, VA. Richmond, VA: Virginia Cooperative Extension Service: 182-185.

Cooperative

Perkey, Arlyn W.; Gottschalk, Kurt W. 1987. Developing silvicultural options to mitigate the moth. Forest management update. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. 6:3-4.

Perkey, Arlyn W.; Gottschalk, Kurt W.; Marquis, David A. 1987. Counting down, gearing up, fighting back. NA-FB/M-10. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Extramural

Labosky, Peter. 1987. Salvaging dead hardwoods. In: Proceedings, Coping with the gypsy moth in the new frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 119-123.

Attainment

Guidelines have been established that will minimize impacts of the gypsy moth in forest stands. Work in Problem Area 2 has produced six publications relating to silvicultural guidelines for forest stands threatened by the gypsy moth and one paper with guidelines on salvaging dead hardwoods in stands suffering heavy mortality. The major emphasis on this problem is to provide the best possible information to forest managers and landowners on how and when to treat stands through silviculture practices to minimize mortality due to gypsy moth defoliation. An historical study is examining the relationship between timing and thinning following defoliation. These publications disseminate the best available information on silvicultural amelioration of the gypsy moth problem and use of these tactics are being used to refine the guidelines as more data becomes available. These accomplishments are directly related to the problem. Technology has been communicated by presentations at meetings, poster displays and brochures to professional and lay people and with a newsletter for professional users. This technology is being implemented and tested in West Virginia by the WV Department of Forestry, Pennsylvania Bureau of Forestry, Maryland Division of Forests, Parks and Wildlife, Ohio Division of Forestry; WESTVACO Paper Co; and by the NFS at the Monongahela and Jefferson National Forests.

Problem 3**DEVELOP AND EVALUATE INTEGRATED PEST MANAGEMENT STRATEGIES TO MANAGE THE GYPSY MOTH
FY 87 Research Attainments**

Publications**Research Unit**

Gottschalk, Kurt W. 1987. Effects of shading on growth & development of northern red oak, blk oak, blk cherry & red maple seedlings. II. Biomass partitioning & prediction. In: Hay, Ronald; Woods, Frank W.; DeSelm, Hal. Proceedings, 1987 Central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 99-110.

Mason, Garland N.; Gansner, David A.; Gottschalk, Kurt W. 1986. Helping forest managers cope with the gypsy moth. In: Proceedings, Integrated pest management symposium for northern forests; 1987 March 24-27; Madison, Wisconsin. Madison, Wisconsin: University of Wisconsin: 216-233.

Extramural

Ravlin, F. William; Bellinger, R. G.; Roberts, E. A. 1987. Gypsy moth management programs in the United States: Status, evaluation and recommendations. Bulletin of the Entomological Society of America. 33: 90-98.

Attainment

The Gypsy Moth Life System Model (GMLSM), a computer model that simulates gypsy moth population dynamics and the effects of defoliation on trees, held workshops on the Parasite-Predator and the Gypsy Moth Submodels. A study on gypsy moth and host phenology was completed with cooperation of the Savage River State Forest in Maryland. The study examined the influence of daily temperature on the development of both gypsy moth larvae and certain host species. Weather is a key factor in GMLSM because of the degree of synchrony. Information from this study is being used to improve the phenology portions of the GMLSM. An IPM paper for managers summarizes state-of-the-art knowledge and organizes it into IPM systems for use by forest managers. A paper that reviews gypsy moth management programs in the U.S. evaluates and provides recommendation of gypsy moth management programs. This information has been disseminated through presentations at users meetings, publications in proceedings, as well as one journal publication. The Pennsylvania Bureau of Forestry is using information from the phenology study to help plan their spray program.

Northeastern Forest Experiment Station
Forest Insect and Disease Research
Research Work Unit 4509

APPLICATIONS OF BIOTECHNOLOGY IN FOREST PEST MANAGEMENT
CHANG, MING TU, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. UNDERSTAND THE GENOMIC STRUCTURE, GENE FUNCTION, AND PATHOGENIC MECHANISM OF GYPSY MOTH NPVs.	FIDR	625	3.0			
2. DEVELOP BACILLUS SUBTILIS AS A BIOLOGICAL CONTROL AGENT OF VASCULAR WILT PATHOGENS.	FIDR	175	3.0	1		

Problem 1 UNDERSTAND THE GENOMIC STRUCTURE, GENE FUNCTION,
AND PATHOGENIC MECHANISM OF GYPSY MOTH NPVs.
FY 87 Research Attainments

Publications

none

Attainment

The gypsy moth nucleopolyhedrosis virus (LdMNPV) is an important biological control agent for the gypsy moth. In order to improve its insecticidal activity for application purpose, it is essential to explore its genomic organization and to analyze its gene structure and function. We have developed an improved procedure for growing the gypsy moth tissue culture. With this protocol, the doubling time is shortened from 81 to 36 hours. Consequently, studies of virus replication in vitro are accelerated. Virus has been plaque-purified and analysis of the genomic restriction map has been completed covering about 70 percent of the genome. We have cloned a 3 Kb Sal I fragment that contained the polyhedrin gene of LdMNPV. This gene is completely sequenced in both orientations. The nucleotide sequence can code for a protein of 28,750 molecular weight with an isoelectric point of 6.83. 5 prime leader sequence contains a highly conserved 12-mer region that is found in all of the hypertranscribed and hypertranslated late genes in the baculovirus family. An additional open reading frame that can code for a polypeptide of 10,000 molecular weight is also identified. These will be potential sites for construction of recombinant viruses to improve the insecticidal potency. Juvenile hormone (JH) plays a central role in insect molting and regulates the larvae-pupae transformation. We have examined the development of the gypsy moth throughout late larval stages to pupation, and identified several morphological and behavioral markers for larval development. This information is extremely useful in the study of hormone regulation. JH level was generally higher in the female larvae during the early stages in the last larval stadium. The level decreases rapidly in both sexes after the larvae attained the maximal body weight. The level remains very low during the pupae stage.

Problem 2**DEVELOP BACILLUS SUBTILIS AS A BIOLOGICAL CONTROL
AGENT OF VASCULAR WILT PATHOGENS.
FY 87 Research Attainments**

Publications**Research Unit**

Chang, Ming Tu; Eshita, Steven M. 1987. A possible novel antibiotic from *Bacillus subtilis* against pathogenic fungi to tree species. In: Genetic Manipulation of Woody Plants: Proceedings of the symposium; 1987 June 21-25; East Lansing, MI. East Lansing, MI: Michigan State University: 3 p.

Attainment

The antibiotic compound(s) has been purified to a high degree of purity and is shown to be active against the fungal pathogen of the Dutch elm disease, *Ceratosystis ulmi*. Analytical methodologies were developed using a series of C-18 reverse phase high pressure liquid chromatography. Purified antibiotic gives a characteristic absorbance spectrum in the ultraviolet wavelength region, typically two peaks centered at 204-207 nm and 285-286 nm. This compound does not contain any amino acid or primary/secondary amine residue. Future work includes methodology development for scale-up production and purification which is underway.

Northeastern Forest Experiment Station
 Forest Insect and Disease Research
 Research Work Unit 4510

**PHYSIOLOGICAL AND BIOCHEMICAL MECHANISMS OF TREE RESPONSE
 TO INJURY AND INFECTION**
 SHORTLE, WALTER, Project Leader

**FY 87 Research Attainments
 Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. A COMPREHENSIVE STUDY OF THE RECIPROCAL RESPONSE SYSTEMS OF HOST AND PATHOGEN IS NEEDED	FIDR	126	1.0	3	8	
2. ADDITIONAL RESEARCH IS NEEDED TO DETERMINE HOW AIR POLLUTION ALTERS WOOD QUALITY	FIDR	126	1.0	1		

Problem 1

**A COMPREHENSIVE STUDY OF THE RECIPROCAL RESPONSE
SYSTEMS OF HOST AND PATHOGEN IS NEEDED
FY 87 Research Attainments**

Publications

Research Unit

Ossenbruggen, Sharon H. 1987. Protecting trees. Lawn Servicing. July: 16-17.

Shortle, W. C.; Hill, J. L. 1987. Ionized oak heartwood associated with checking during kiln drying. *Holzforschung*. 41 (3): 133-136.

Shortle, Walter C.; Smith, Kevin T. 1987. Electrical properties and rate of decay in spruce and fir wood. *Phytopathology*. 77 (6): 811-814.

Extramural

Shigo, Alex L. 1986. A new tree biology dictionary: terms, topics, and treatments for trees and their problems and proper care. Durham, NH: Shigo and Trees Associates. 132 p.

(Material for this book was obtained while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L. 1986. A new tree biology: facts, photos, and philosophies on trees and their problems and proper care. Durham, NH: Shigo & Trees Associates; 595.

(The work reported in this book was done while Dr. Shigo was employed by the Forest Service.)

Shigo, Alex L. 1986. Tree decay. *International Journal of Tropical Plant Diseases*. 4: 95-121.

(This work was done while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L.; Vollbrecht, Klaus; Hvass, Niels. 1987. *Biologie der Baume und Baumpflege*. Ballerup, Denmark: SITAS. 137.

(Cooperation with K. Vollbrecht and N. Hvass was established while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L.; Vollbrecht, Klaus; Hvass, Niels. 1987. *Boomverzorging en de biologie van bomen*. Ballerup, Denmark: SITAS. 137.

(Cooperation with K. Vollbrecht and N. Hvass was established while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L.; Vollbrecht, Klaus; Hvass, Niels. 1987. *Tradens biologi och travard*. Ballerup, Denmark: SITAS. 137.

(Cooperation with K. Vollbrecht and N. Hvass was established while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L.; Vollbrecht, Klaus; Hvass, Niels. 1987. *Traebiologi og traepjeje*. Ballerup, Denmark: SITAS. 137.

(Cooperation with K. Vollbrecht and N. Hvass was established while Dr. Shigo was employed by the Forest Service)

Shigo, Alex L.; Vollbrecht, Klaus; Hvass, Niels. 1987. *Tree biology and tree care*. Ballerup, Denmark: SITAS. 137.

(Cooperation with K. Vollbrecht and N. Hvass was established while Dr. Shigo was employed by the Forest Service)

Attainment

Results of 26 years of Forest Service research are being brought together by Dr. Alex L. Shigo (retired) and presented to international audiences as a new tree biology. The conceptual models of Shigo are based on thousands of tree dissection experiments and provide a basis for the mechanistic work being done on the host-pathogen interactions which alter wood properties in living trees. The mechanisms of wood infection, and the response of live cells in wood to limit the spread of infection, both involve changes in ions in the tissue. These changes can be observed by electrical resistance measurements, which help to differentiate tissues in progressive stages of alteration. Further study of tissue samples by chemical analysis and bioassays is beginning to yield information about the biological processes taking place in wood, and how these processes affect the quality of wood in forest trees, the processing of wood into forest products, and the care of trees in the homesite, the park, the recreation areas, and other places where people and trees are in close association. Results were published in each of these major areas of concern. Experiments were initiated to continue to expand our knowledge of the vital processes which keep trees alive and healthy.

Problem 2

**ADDITIONAL RESEARCH IS NEEDED TO DETERMINE HOW AIR
POLLUTION ALTERS WOOD QUALITY
FY 87 Research Attainments**

Publications

Research Unit

Shortle, Walter C.; Bauch, Josef. 1986. Wood characteristics of *Abies balsamea* in the New England States compared to *Abies alba* from sites in Europe with decline problems. *IAWA Bulletin*. 7 (4): 375-387.

(Work was done with Prof. Dr. Bauch at the University of Hamburg through a cooperative agreement.)

Attainment

A study of the structural features and physiological parameters of the balsam fir in the northeastern United States and silver fir in the Federal Republic of Germany was published. Changes in structural features of declining trees of both species were similar, but differences in physiology may explain why balsam fir does not survive long enough to express the degree of symptoms observed in declining silver fir. Work on fine roots in fir and spruce was completed and is being prepared for publication. A model of how fine root effects related to acidity, release of aluminum from soil solids, interference with fine root uptake of calcium, and the consequences for the vascular cambium, sapwood, and foliage is being developed. Wound experiments to observe the response of healthy and declining spruce and fir trees were initiated in the United States, Federal Republic of Germany, and Yugoslavia. A three-year cooperative research program was initiated in September 1987 with Dr. Nikolaj Torelli, Edvard Kardelj University of Ljubljana, Yugoslavia.

Northeastern Forest Experiment Station
Forest Products and Harvesting Research
Research Work Unit 4701

INCREASING USE OF EASTERN HARDWOODS THROUGH BETTER
PROCESSING WITH IMPROVED TECHNOLOGY
GATCHELL, CHARLES, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. NEW, ECONOMICAL, INTEGRATED CONVERSION SYSTEMS FROM SAWMILL LOG DECK THROUGH THE ROUGH MILL	FPHR	203	1.0	3		
2. QUANTITATIVE AND QUALITATIVE YIELDS OF HIGH-VALUED PRODUCTS PARTS	FPHR	203	1.2	3	1	

Problem 1**NEW, ECONOMICAL, INTEGRATED CONVERSION SYSTEMS
FROM SAWMILL LOG DECK THROUGH THE ROUGH MILL
FY 87 Research Attainments**

Publications**Research Unit**

Adams, E.L. 1987. PC-SOLVE II: IBM-compatible analysis system for hardwood sawmills. *The Northern Logger and Timber Processor*. 35 (9): 18-19, 27.

Adams, Edward L. 1987. PC-SOLVE II user's manual: a procedural guide for the microcomputer version of SOLVE II sawmill analysis tool. Gen. Tech. Rep. NE-116. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Adams, Edward L. 1987. DESIM: what can it do for you? In: White, Julia L., ed. *Proceedings of innovations in milling and machining*; 1986 May 15-17; Louisville, KY. Madison, WI: Forest Products Research Society: 60. Abstract.

Attainment

A computer simulator is being developed for designing and evaluating new furniture rough mills and for designing and evaluating modifications to existing rough mills. It will handle (1) rip-first mills; (2) crosscut-first mills; (3) combination rip-first, crosscut-first mills; and (4) laser "cookie cutter" type mills. It will allow the simulation of processing beyond the square edged parts traditionally considered products of the rough mill and will include the machining of actual furniture parts (i.e., router parts, glued-up blanks, and turnings). In addition to the ability of simulating the operation of conventional processing equipment, the simulator will allow the simulation of computer controlled equipment and robots. To assist in the evaluation of different mill designs and operating procedures, a cost routine will be added to the simulator to provide realistic costs for producing each product part. The simulator will be especially helpful in evaluating new computer controlled mill systems.

SOLVE II is a computerized system for evaluating the operation of hardwood sawmills that has been widely used (1500 sawmills since 1978). To answer the demand for a microcomputer version, PC-SOLVE II was developed. The availability of this PC version was published in *The Northern Logger and Timber Processor* (citation 3). This has resulted in the distribution of over 50 copies of the program and related user's manual in the U.S. and Canada this year.

Problem 2**QUANTITATIVE AND QUALITATIVE YIELDS OF HIGH-VALUED
PRODUCTS PARTS
FY 87 Research Attainments**

Publications**Research Unit**

Gatchell, Charles J. 1987. Impact of rough-mill practices on yields. In: Eastern hardwoods: the resource, the industry, & the market; 1985 September 9-11; Harrisburg, PA. Madison, WI: Forest Products Research Society: 146-156.

Gatchell, Charles J. 1987. Rethinking the design of the furniture rough mill. Forest Products Journal. 37 (3): 8-14.

Gatchell, Charles J. 1987. Want to use more low-grade lumber? Why not rip first. Wood & Wood Products. 92 (8): 113-115.

Extramural

Abdullah, Nazri B. 1987. Comparison of the drying rate and yield between System-6 boards and defect-free precut parts of northern red oak (*Quercus rubra*). Amherst, MA: University of Massachusetts. 71 p. M.S. thesis.

Attainment

The most significant decision made in the design of a furniture rough mill is whether to gang rip or crosscut lumber first. The most important factors affecting this decision are lumber quality, cutting bills, and operator skills. Forest Service research shows that gang ripping of No. 2 Common lumber will meet the parts needs of the furniture and cabinet industries. Gang rip procedures that eliminate the generation of edgings should be used. The gang rip process itself can be set up in several ways that will affect the length and width distributions of parts. Provided a sufficient range of lengths are used, total gang rip first yields are not affected by setups but part size distributions are. New rough mill designs should probably allow a choice of gang ripping or crosscutting first. The decision for each board would depend on board size, quality, and straightness.

Northeastern Forest Experiment Station
Forest Products and Harvesting Research
Research Work Unit 4702

**FOREST ENGINEERING RESEARCH-TIMBER HARVESTING SYSTEMS AND
EQUIPMENT FOR STEEP TERRAINS**
PETERS, PENN A., Project Leader

**FY 87 Research Attainments
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. LACK OF SUITABLE TIMBER HARVESTING SYSTEMS AND EQUIPMENT IN STEEP TERRAIN	FPHR	290	3.0	16		3

Problem 1

LACK OF SUITABLE TIMBER HARVESTING SYSTEMS AND EQUIPMENT IN STEEP TERRAIN FY 87 Research Attainments

Publications

Research Unit

Baumgras, John E. 1987. Hooking rules increase cable yarder productivity. *Northern Journal of Applied Forestry*. 4 (1): 33-35.

Baumgras, John E. 1987. Production study of the Swedish Rottne-Snoken 810 harvester/processor in Pennsylvania softwood plantations. In: *Proceedings, Improving productivity through forest engineering*; 1986 September 29-October 2; Mobile, AL. Corvallis, OR: Council on Forest Engineering: 63-68.

Biller, Cleveland J. 1987. Design features of a two-loadline Christy carriage. In: *Proceedings, High technology in forest engineering*, SUNY-CESF; 1987 August 3-6; Syracuse, NY. Corvallis, OR: Council on Forest Engineering: 281-286.

Biller, Cleveland J. 1987. Review of two-drum yarders in northern Appalachia. ASAE Paper No. 87-6011. St. Joseph, MI: American Society of Agricultural Engineers. 9 p.

Biller, Cleveland J.; Baumgras, John E. 1986. Analysis of rubber-tired skidder cycle time on steep slope hardwood sites. ASAE Paper No. 86-1610. St. Joseph, MI: American Society of Agricultural Engineers. 17 p.

Biller, Cleveland J.; Baumgras, John E. 1986. Failure loads on small-diameter hardwood stumps. ASAE Paper No. 86-1595. St. Joseph, MI: American Society of Agricultural Engineers. 13 p.

Biller, Cleveland J.; Johnson David D., inventors; U.S. Department of Agriculture, assignee. 1987. Apparatus for maintaining stability of mobile land vehicles on sloping terrain. U.S. Patent 4,679,803. July 14. Cl 4 B60P 1/18; B60G 17/00.

Biller, Cleveland J.; Johnson, David D., inventors; U.S. Department of Agriculture, assignee. 1987. Locking balls for logging carriage. U.S. Patent 4,615,532. Oct. 7. Int. Cl 4 F160 11/00.

Johnson, David D.; Biller, Cleveland J., inventors; U.S. Department of Agriculture, assignee. 1987. Auto-release logging choker. U.S. Patent 4,637,643. January 20. Cl 4 B66C 1/38; F16F 15/06.

LeDoux, Chris B. 1986. Bucking logs to cable yarder capacity can decrease yarding costs and minimize wood wastage. *Southern Journal of Applied Forestry*. 10 (3): 180-183.

LeDoux, Chris B. 1986. How to develop regional stump-to-mill timber production cost estimators. *Northern Journal of Applied Forestry*. 3 (4): 132.

LeDoux, Chris B. 1986. MANAGE - A computer program to estimate costs and benefits associated with eastern hardwood management. Gen. Tech. Rep. NE-112. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

LeDoux, Chris B.; Kling, Bruce W.; Harou, Patrice A. 1987. Predicting bunching costs for the Radio Horse 9 winch. Res. Pap. NE-595. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Peters, Penn A. 1987. Close to markets, too close to people. In: *Executive summary: Hardwood harvesting problems and opportunities: Proceedings, Forest Products Research Society 41st annual meeting*; 1987 June 21-24; Louisville, KY. Madison, WI: Forest Products Research Society: 2 p.

Peters, Penn A.; Biller, Cleveland J. 1986. Preliminary evaluation of the effect of vertical angle of pull on stump uprooting failure. In: *Proceedings, Improving productivity through forest engineering*; 1986 September 29-October 2; Mobile, AL. Corvallis, OR: Council on Forest Engineering: 90-93.

Peters, Penn A.; Biller, Cleveland J.; Johnson, David D., inventors; U.S. Department of Agriculture, assignee. 1987. Transport carriage. U.S. Patent 4,629,079. December 16. Int. Cl 4 B66C 117/06; B66C 21/00.

Cooperative

Eck, Ronald W. 1987. A microcomputer program to assist in low-volume road maintenance management. Transportation Research Record 1128. Washington, DC: Transportation Research Board, National Research Council. 62-68.

(In cooperation with: U.S. Department of Agriculture, Forest Service and West Virginia University. Extramural research funded by NE-4702.)

Eck, Ronald W.; Morgan, Perry J. 1987. Culverts versus dips in the Appalachian Region: A performance-based decision making guide. Transportation Research Record 1106. Washington, DC: Transportation Research Board, National Research Council. 330-340.

Fridley, G. E.; Fridley, J. L.; Jorgensen, J. E.; Mann, C. N. 1986. Analysis and design of long booms for feller-bunchers in thinning operations. Transactions of ASAE. St. Joseph, MI: American Society of Agricultural Engineers. 29 (3): 696-701.

(Extramural research funded by NE-4702.)

Attainment

Cable logging has returned in this decade as a forest harvesting technique on the steep terrain of the Eastern United States after a hiatus of approximately 50 years. Cable logging is easy on the environment, primarily because it requires a less dense road system on steep terrain than rubber-tired skidding. An obstacle to greater use of cable logging is the high cost of yarding. The disadvantage of higher yarding costs is especially limiting if the offsetting costs of fewer roads and less environmental damage are not included in logging system comparisons. If cable logging costs can be reduced, use of this beneficial harvesting technique on environmentally sensitive, steep terrain sites could be increased.

Forest Service researchers at Morgantown, WV, have invented a cable logging carriage that promises to reduce cable logging costs (Patent Nos. 4,500,004 and 4,629,079). The unique feature of the carriage is the use of two separate loadlines instead of the customary one loadline. With two loadlines, theoretically twice as many logs could be yarded in each cycle. Most carriages using one loadline yard an average of 2.5 logs per cycle; the corresponding weight of logs yarded per cycle is only 40 percent of the capacity of the yarder. The two loadline carriage has the potential to substantially increase the average number of logs (and weight) yarded each cycle without significantly increasing the cycle time, thereby reducing costs.

Based on a literature review and field survey, specific factors that need to be considered in the decision to use culverts or broad-based dips for cross-drainage on low-volume roads have been identified.

Northeastern Forest Experiment Station
Forest Products and Harvesting Research
Research Work Unit 4751

**SYSTEMS TO INTEGRATE HARVESTING WITH OTHER RESOURCE
MANAGEMENT OBJECTIVES**
LEDOUX, CHRIS B., Project Leader

**FY 87 Research Attainments
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. INADEQUATE FOREST MANAGEMENT PLANNING TOOLS FOR STEEP TERRAIN	FPHR	95	1.0			
2. INADEQUATE METHODS TO PLAN/CARRY OUT MULTIPROD. HARVEST./UTIL. OF E. HARDWOOD ON STEEP TERRAIN	FPHR	95	1.0			

Problem 1

**INADEQUATE FOREST MANAGEMENT PLANNING TOOLS FOR
STEEP TERRAIN
FY 87 Research Attainments**

Publications

none

Attainment

The goal of this research is to develop a system analysis computer model that adequately models the biological, technological, economical and silvicultural treatment of a forest stand over a rotation. The research will involve a detailed evaluation of cable and ground-based harvesting systems and their influence on forest management prescriptions over the entire rotation period. Progress includes the programming of a shell for the integrative model and initial documentation. Detailed stump-to-mill timber production models have been developed and linked with a growth model to conduct preliminary cost/benefit analysis. A detailed ground-based harvesting cost estimating model is also being developed.

Results demonstrate that the use of cable logging technology to manage young hardwood stands on steep terrain will dictate few entries with heavy volume removals to maximize net values. The models developed are needed by the forest industry to develop management guidelines for hardwood management on steep terrain. These analytical models will enable forest managers and planners to integrate harvesting, silviculture, and economics in a long term decision-making manner.

NE-4751 publications are entered under Project NE-4702.

Problem 2**INADEQUATE METHODS TO PLAN/CARRY OUT MULTIPROD.
HARVEST./UTIL. OF E. HARDWOOD ON STEEP TERRAIN
FY 87 Research Attainments**

Publications

none

Attainment

Research objectives are to develop the harvesting cost and revenue models required to define economic opportunities for implementing multiproduct harvesting, and thereby improve the management and utilization of the eastern hardwood resource. These opportunities can be defined in terms of timber stand attributes, product markets, harvesting technology, and silvicultural objectives. Progress includes a regional survey of product markets, and the application of these results via a product yield program, to estimate harvest revenue gains from multiproduct versus single product thinnings in Appalachian hardwoods. This research has also developed an economic model that integrates the incremental costs and revenues associated with product utilization alternatives to analyze resulting shifts in harvesting profits or stumpage payments.

Results demonstrate multiproduct harvesting can provide significant revenue gains; but these gains are extremely variable, depending on product price differentials, market locations, the diameter of trees harvested, and the resulting product mix. Consequently, the methodology developed and demonstrated is needed by the forest industry to identify specific opportunities for jointly increasing utilization and profits. These analytical tools will also enable forest managers to incorporate product market and timber stand data in the planning of cultural treatments and final harvests.

Northeastern Forest Experiment Station
Forest Inventory and Economic Research
Research Work Unit 4801

FOREST INVENTORY, ANALYSIS AND ECONOMICS
PETERS, JOHN, Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. MULTI-RESOURCE DATA	FIA	670	2.0	5		2
2. FOREST RESOURCE INFORMATION	FIA	513	.5	5		1
3. FOREST RESOURCE MODELING AND INTERACTION ANALYSIS	FIA	0	.0			
4. RENEWABLE RESOURCE USE AND FOREST INDUSTRY PRODUCTION	FIA	489	.5	5		1
5. RESOURCE ISSUES AND CONCERNS	FIA	405	1.8	4		2

Problem 1

MULTI-RESOURCE DATA
FY 87 Research Attainments

Publications

Research Unit

Brooks, Robert T. 1986. Forest land wildlife habitat resources of South-Central Ohio. Resour. Bull. NE-94. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 31 p.

Brooks, Robert T.; Frieswyk, Thomas S.; Malley, Anne M. 1987. Forest wildlife habitat statistics for New Hampshire-1983. Resour. Bull. NE-97. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 107 p.

Brooks, Robert T.; Frieswyk, Thomas S.; Ritter, Arthur. 1987. Forest wildlife habitat statistics for Maine-1982. Resour. Bull. NE-96. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 146 p.

Scott, Charles T.; Schreuder, Hans T.; Griffith, Douglas M. 1987. A comparison of optical bar, high-altitude, and black-and-white photography in land use estimation. Photogrammetric Engineering and Remote Sensing Journal. 53 (2): 203-206.

Scott, Charles T.; Voorhis, Nancy G. 1986. Northeastern forest survey site index equations and site productivity classes. Northern Journal of Applied Forestry. 3 (4): 144-148.

Cooperative

Green, Edwin J.; Scott, Charles T. 1987. Simulation of subsampling selection rules for hardwood tree heights. In: Proceedings of the 6th central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 443-448.

Schrueder, Hans T.; Li, H. G.; Scott, Charles T. 1987. Jackknife and bootstrap estimation of sampling with partial replacement. Forest Science. 33 (3): 676-689.

Attainment

For the first time in history, comprehensive inventories of forest wildlife habitat were completed in New Hampshire, Maine and Ohio. Results include information on land use patterns, mast potential, standing dead and cavity trees and understory woody-stemmed vegetation. Findings are related to forest wildlife habitat quality conditions. Some new techniques for analyzing the status of the forest resource were developed and evaluated. Results of using optical bar, high altitude and black and white photography in land classification were compared. For surveys of large forest areas, color infrared national high altitude program (NHAP) and optical bar color (OBC) infrared photography resulted in equally precise estimates of land use. Both were more precise than black and white photography. Polymorphic site index equations for 19 tree species in the Northeast have been developed for determining the productivity of forest sites. They will facilitate analyses of forest growth and potential productivity. Jackknife and bootstrap estimators and variance estimators were compared with a classical estimator and variance estimator for sampling with partial replacement (SPR) on two occasions. Choice of estimators depends on purpose of the sample. For example, the classical estimator is generally preferable to the jackknife and bootstrap estimators when both estimation bias and efficiency are important in SPR sampling. Results of this research have been presented to resource managers, policy makers and other researchers through resource bulletins, workshops and other appropriate outlets.

Problem 2

FOREST RESOURCE INFORMATION
FY 87 Research Attainments

Publications

Research Unit

Birch, Thomas W. 1986. Communicating with nonindustrial private forest-land owners. *Journal of Forestry*. 84 (12): 25-33.

Birch, Thomas W.; Pywell, Nancy A. 1986. Getting programs on target. *Journal of Forestry*. 84 (12): 27.

Birch, Thomas W.; Spencer, John S., Jr. 1987. Hardwoods in the North. In: *The Northern Hardwood Resource: Management and Potential*; 1986 August 18-20; Houghton, MI. Houghton, MI: Michigan Technological University: 1-11.

Gansner, David A; Dale, Martin E.; Herrick, Owen W.; Dickson, David R.; Lutz, David E. 1987. Silvicultural cutting opportunities in oak-hickory forests. *Northern Journal of Applied Forestry*. 4 (2): 59-63.

Wharton Eric H. 1987. Availability of woody residuals in Southwestern New York and North-central Pennsylvania. In: *Petroleum Production Solids and Woody Residuals: Waste or Resource?*; 1987 May 14; Bradford, PA. Bradford, PA: University of Pittsburgh at Bradford; IV: 1-19.

Cooperative

McWilliams, William H.; Sheffield, Raymond M.; Hansen, Mark H.; Birch, Thomas W. 1987. The shortleaf resource. In: *Symposium on the Shortleaf Pine Ecosystem*; 1986 March 31-April 2; Little Rock, AR. Fayetteville, AR: University of Arkansas: 9-24.

Attainment

Private nonindustrial forest land owners are making decisions that affect 58 percent of the Nation's timberland. But methods for getting forest management information to them have not been adequate. New approaches to communication are being explored to get programs on line. One of them recommends the generation of owner group profiles from survey data to identify potential targets followed by more effective use of multi media to carry the message. Analysis of recent forest inventories in the north depict an expanding hardwood resource. Some species are being overutilized in particular locations. But overall, hardwood timber is growing faster than its being cut and the surplus is accumulating. Growing stock volume has shown increases in all diameter classes. A recent study of aboveground tree biomass in New York and Pennsylvania shows that even though timber utilization has improved, current harvesting still makes use of only half of the total wood fiber available. Timberlands in southwestern New York and north central Pennsylvania contain about 98 green tons of aboveground tree biomass per acre. Analysis of cutting opportunities for oak hickory forests of Pennsylvania reveals a timber bonanza for expanding wood using plants. The current potential cut from silvicultural thinning, regeneration and harvesting opportunities totals 58 million cords. On the stump, the conversion value of this material totals 615 million dollars. Results of this research have been presented to resource managers, policy makers and other researchers through resource bulletins, workshops and other appropriate outlets.

Problem 3**FOREST RESOURCE MODELING AND INTERACTION ANALYSIS
FY 87 Research Attainments**

Publications

none

Attainment

No progress. Work unit has been recruiting for a scientist to begin work in this problem area. In addition, cooperative research activities with other FS projects and universities are being explored.

Problem 4**RENEWABLE RESOURCE USE AND FOREST INDUSTRY
PRODUCTION
FY 87 Research Attainments**

Publications**Research Unit**

Nevel, Robert L., Jr.; Blyth, James E. 1987. Veneer log production and receipts in the Northeastern and North-central States in 1984. *The Northern Logger and Timber Processor*. 35 (10): 52-54.

Nevel, Robert L., Jr.; Wharton, Eric H. 1987. Veneer log production and receipts in the Northeast, 1984—A periodic assessment of regional timber output. *Resour. Bull. NE-98*. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 17 p.

Wharton, Eric H.; Nevel, Robert L., Jr.; Powell, Douglas S. 1987. Supply and demand of timber for wood turning in Maine. *Res. Pap. NE-599*. Broomall: PA. 29 p.

Widmann, Richard H. 1987. Pulpwood production in the Northeast—1985. *Resour. Bull. NE-99*. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.

Widmann, Richard H.; Long, Michael. 1986. Ohio timber products output—1983. *Resour. Bull. NE-95*. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

Cooperative

Blyth, James E.; Widmann, Richard H. 1987. Pulpwood production in 1985: Moderate decline from 1984 record. *The Northern Logger and Timber Processor*. 35 (8): 20-21.

Attainment

Estimates of the current use of timber growing in the forests of the Northeast for industrial wood products are necessary for meaningful forest management decisions. Canvasses of the primary producers of wood products coupled with studies that develop the linkage coefficients to express roundwood product measures in standing tree growing stock equivalents are regularly conducted by the unit. Results are in constant demand. The 1985 annual assessment of pulpwood production in the Northeast showed that production dipped 2 percent below that of 1984. Roundwood production decreased 3 percent and manufacturing residues was down 1 percent. Total production amounted to 8.8 million cords. Consumption of pulpwood at Northeast mills totaled 9.5 million cords. A survey of wood turned product manufacturers in Maine indicates their primary sources of wood raw material are sugar maple, yellow birch and paper birch. Other suitable and abundant species such as red maple and aspen are used sparingly. The resource supply of primary species used by the industry has been increasing but most of the increase has been in smaller diameter classes. A survey of northeastern veneer log production in 1984 revealed a 19 percent increase over 1980. Production totaled 183.7 million board feet. Veneer log receipts at northeastern mills rose 28 percent to 154 million board feet, even though five fewer plants are operating in the region. Results of this research have been presented to resource managers, policy makers and other researchers through resource bulletins, workshops and other appropriate outlets.

Problem 5

RESOURCE ISSUES AND CONCERNS
FY 87 Research Attainments

Publications**Research Unit**

Gansner, David A.; Herrick, Owen W. 1987. Estimating the benefits of gypsy moth control on timberland. Res. Note. NE-337. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Gansner, David A.; Herrick, Owen W. 1987. Impact of gypsy moth on the timber resource. In: Coping with the Gypsy Moth in the New Frontier; 1987 August 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 11-20.

Herrick, Owen W.; Gansner, David A. 1987. Gypsy moth on a new frontier: forest tree defoliation and mortality. Northern Journal of Applied Forestry. 4 (3): 128-133.

Wharton, Eric H.; Cunia, Tiberius. 1987. Estimating tree biomass regressions and their error: Proceedings of the workshop on tree biomass regression functions and their contribution to the error of forest inventory estimates. Gen. Tech. Rep. NE-117. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 303 p.

Cooperative

Mason, Garland N.; Gansner, David A.; Gottschalk, Kurt W. 1987. Helping forest managers cope with the gypsy moth. In: Integrated Pest Management Symposium for Northern Forests; 1986 March 24-27; Madison, WI. Madison, WI: University of Wisconsin: 216-233.

Phillips, Ross A.; Powell, Douglas S. 1986. Timber volume relative to slope. In: Forest Operations in Politically and Environmentally Sensitive Areas: A Proceedings of the Council on Forest Engineering; 1985 August 18-22; Tahoe City, CA. Davis, CA: University of California, Davis: 41-45.

Attainment

Gypsy moth is one of the most critical problems facing forest land managers in the Northeast. Recent studies in infested areas have provided a basis for improved decisions for coping with the pest. Tree mortality on study plots over a five year period averaged 18 percent. Plots that averaged less than 10 percent defoliation lost 13 percent of their trees. Where defoliation averaged 40 percent or more, the average tree loss was 28 percent. Protecting highly susceptible trees from impending attack can prevent a potential loss of 15 percent in their timber value and 2.8 percent in their compound rate of value growth. Oak timber, which has borne the brunt of gypsy moth attacks, accounts for a smaller percentage of the total hardwood inventory than it used to. But other less vulnerable species such as red maple, ash, and yellow poplar have grown to take up the slack. There has been very little effect on average stocking. The error associated with biomass table development can have a significant influence on the sampling error of an estimate. Procedures exist to include the error of biomass tables when the error of the biomass inventory estimates are calculated, but they have not been readily available. Therefore, a workshop for estimating tree biomass regressions and their error was conducted. Does forest slope have any effect on timber availability? A study conducted on fairly rugged terrain in Maine showed no change in timber size or volume with respect to slope. Results of this research have been presented to resource managers, policy makers and other researchers through resource bulletins, workshops and other appropriate outlets.

Northeastern Forest Experiment Station
Forest Inventory and Economic Research
Research Work Unit 4803

AN ANAL. OF DOMESTIC & INTERNATIONAL DEMANDS FOR HARDWOOD
LUMBER & VENEER & DOMESTIC SUPPLIES OF THESE PRODUCTS
LUPPOLD, WILLIAM G., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. PHYSICAL AND ECONOMIC FACTORS AFFECTING FURNITURE DEMANDS FOR HARDWOOD LUMBER	FPHR	153	1.0	4		
2. PHYSICAL AND ECONOMIC FACTORS AFFECTING THE DEMAND AND SUPPLY OF PALLETS	RREc	207	1.8	4	1	2
3. ECONOMIC AND TECHNICAL FACTORS AFFECTING INTERNATIONAL TRADE OF HARDWOOD PRODUCTS.	RREc	206	1.7	7		
4. EFFECT OF TECHNOLOGY, CAPITAL COSTS, WAGE RATES, AND LOG COSTS ON SUPPLY OF HARDWOOD LUMBER.	RREc	187	1.5	2	4	1

Problem 1**PHYSICAL AND ECONOMIC FACTORS AFFECTING FURNITURE
DEMANDS FOR HARDWOOD LUMBER
FY 87 Research Attainments**

Publications**Research Unit**

Luppold, William G. 1987. Can hardwood lumber prices be predicted?. Furniture Design & Manufacturing. 58 (11): 98, 100, 103-4.

Luppold, William G. 1987. Material usage trends in the wood household furniture industry. Res. Pap. NE-600. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Luppold, William G. 1987. The changing hardwood lumber market. In: 6th central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 401-408.

Martens, David G. 1986. Produce yellow-poplar furniture dimension at minimum cost by using YELLOPOP. Res. Pap. NE-592. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

Attainment

Usage of hardwood lumber, plywood, and veneer products in furniture production has fluctuated because of changes in the level of furniture production, styling, and production technology (citation 1). Hardwood lumber, plywood, and veneer usage decreased in relative terms (usage per piece of furniture) between the 1960's and mid-1970's. Since the mid-1970's, lumber use has increased in relative terms while plywood and veneer use has continued to decrease because of composite product substitution. Price is a major factor influencing hardwood lumber usage (citations 2, 3). Price is primarily influenced by domestic and foreign demand. Lumber is still the most costly input used in furniture production. Determination of minimum production cost, given a cutting order and cost of various grades of lumber, can be obtained through use of the OPTIGRAMI program developed at the Princeton, WV laboratory (citation 4). Information on the demand for hardwood products by the furniture industry and the factors affecting hardwood lumber demand are important ingredients in the determination of long-term hardwood timber demand. Information on factors affecting hardwood lumber price is also used by industry in short- and long-run decisionmaking. The OPTIGRAMI system of determining maximum lumber yield is available nationwide through the Computer Management Network at Virginia Polytechnic Institute at Blacksburg, VA.

Problem 2

**PHYSICAL AND ECONOMIC FACTORS AFFECTING THE DEMAND
AND SUPPLY OF PALLETS
FY 87 Research Attainments**

Publications

Research Unit

Anderson, R. Bruce. 1986. Future availability of pallet raw material in the South. *Pallet Enterprise*. 6 (6): 44-46.

Anderson, R. Bruce. 1987. Future availability of pallet raw material in the North. *Pallet Enterprise*. 7 (3): 31-32, 34.

Luppold, William G. 1987. Competition and the pallet industry. *Pallet Enterprise*. 7 (2): 40, 42.

Wallin, Walter B. 1986. Pallets, wood. New York, NY: John Wiley & Sons; In: *The Wiley encyclopedia of packaging technology*. 492-496.

Cooperative

McLain, T.E.; Spurlock, H.W., Jr.; McLeod, J.A. III; Wallin, W.B. 1986. The flexural properties of eastern oak pallet lumber. *Forest Products Journal*. 36 (9): 7-15.

Sullenberger, Diane; Wallin, Walt. 1986. Computer programs aid pallet manufacturers. *Women in Forestry*. 8 (2): 28.

Extramural

McCurdy, Dwight R.; Ewers, James T.; Kung, Fan H. 1986. A study of lumber use in pallets manufactured in the United States 1982 and 1985. Carbondale, IL: Southern Illinois University. 49 p.

Attainment

The pallet industry is the major consumer of sawn hardwood material and is an important user of lower quality hardwood lumber and timber. Adequate availability of lumber and timber for the pallet industry will influence the overall level of pallet production and material use (citations 1 and 2). Analysis completed at Princeton indicates that a surplus of timber that can be used by the pallet industry will exist in both northern and southern regions of the Eastern United States through the year 2000. Competitive market forces influence the level of pallet production and the type of pallet being produced (citation 3). Competitive forces have caused pallet producers to reduce cost and lumber use per pallet, but reduced pallet prices have probably increased overall pallet demand and lumber use. Pallet supply could be improved through better pallet design (citations 4, 5, and 6). Technical aspects of pallet design and technical characteristics of major pallet species such as oak are essential ingredients in the development of a computerized pallet design system. Such a system has been developed by the staff at Princeton in cooperation with scientists at Virginia Tech and the Forest Products Laboratory at Madison, WI. Information on availability of raw material for the pallet industry and the effect of competition on pallet supply will be utilized in the determination of timber demand resulting from pallet production. The pallet design system is available for use by the pallet industry through the Sardo Pallet Research Laboratory at Virginia Tech at Blacksburg, VA.

Problem 3

**ECONOMIC AND TECHNICAL FACTORS AFFECTING
INTERNATIONAL TRADE OF HARDWOOD PRODUCTS.
FY 87 Research Attainments**

Publications

Research Unit

Araman, Philip A. 1986. Implications of international trade for northern hardwoods. In: The northern hardwood resource: management and potential; 1986 August 18-20; Houghton, MI. Michigan Technological University: 391-412.

Araman, Philip A. 1987. Export markets for value-added forest products-hardwood panel and specialty products. In: Plenary session IB: export markets for value-added forest products: executive summary of the 41st annual meeting of the Forest Products Research Society Society; 1987 June 21-24; Louisville, KY. Madison, WI: Forest Products Research Society: 3 p.

Araman, Philip A. 1987. Standard sizes for rough-dimension exports to Europe and Japan. Wood & Wood Products. 92 (6): 84, 86.

Araman, Philip A. 1987. The oriental market for North American hardwoods. In: Marketing logs, timber, lumber, and chips to the Pacific Rim: Abstracted Proceedings of 3rd annual Seattle conference; 1986 December 8-9; Seattle, WA. Jay Gruenfeld Associates, Inc.: 63-66c.

Araman, Philip A.; Hansen, Bruce G. 1987. Log, lumber, and veneer hardwood export markets. In: 6th central hardwood forest conference; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 387-394.

Hansen, Bruce G. 1986. Program TREND: using shift-share analysis to analyze forest industry change. In: Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. Morgantown, WV: West Virginia University: 379-387.

Ringe, James M.; Graves, Donald H.; Hansen, Bruce G. 1987. Characteristics and marketing methods of Kentucky hardwood lumber exporters. Forest Products Journal. 37 (5): 31-34.

Attainment

The export market for logs, lumber, and veneer has been the most dynamic part of the overall hardwood product market. In the 1960's, Canada was the major importer of domestically-produced hardwood products (citation 1). During the 1970's, Europe became the major demander of hardwood products. By the mid-1980's, the Asian market became a major force with Taiwan being the single biggest importer of domestically-produced hardwood products (citation 2). Much of the material destined for Taiwan, however, is shipped back to the United States in the form of furniture and furniture parts. A shift share analysis program was developed by Princeton's staff that allows exporters to analyze change demands by various countries or individual firms (citation 3). International trade impacts the forest resource by placing strong demand on higher grade hardwood timber (citation 4). The export market currently uses limited amounts of lower grade hardwood material. The Princeton staff has developed a set of standard sizes of rough dimension that can be utilized by foreign users (citations 5 and 6). Adaptation of these sizes may allow domestic producers to develop exportable products from lower grade hardwood lumber. A case study of lumber exporters indicated that maintaining overseas contact and the desire to serve customers were more important to successful exporting than the size of the firm (citation 7). Information developed in this research will be used to develop long term material use information and aid industry in their efforts to market U.S. products abroad.

Problem 4**EFFECT OF TECHNOLOGY, CAPITAL COSTS, WAGE RATES, AND LOG COSTS ON SUPPLY OF HARDWOOD LUMBER.
FY 87 Research Attainments**

Publications**Research Unit**

Dempsey, Gilbert P. 1987. Variations in productivity and performance in grade lumber industries in Kentucky, Pennsylvania, and West Virginia-1982. Res. Pap. NE-604. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 18 p.

Hansen, Bruce G. 1986. Selecting a tax rate for use in analyzing forest industry capital investment. Northern Journal of Applied Forestry. 3 (3): 101-103.

Cooperative

Brock, Samuel M.; Anderson, R. Bruce; Ruan, Joshua O. 1986. Developing and testing models for predicting hardwood stumpage prices in West Virginia. West Virginia Forestry Notes No. 12. Morgantown, WV: West Virginia University. 7-10.

Extramural

Bush, Robert J. 1986. An analysis of the capital budgeting sophistication of primary forest products firms in the eastern United States. Blacksburg, VA: Virginia Polytechnic Institute and State University. 96. M.S. thesis.

Hardie, Ian W.; Abu Hassan, Aziz. 1986. An econometric analysis of residential demand for fuelwood in the United States, 1980-81. Forest Science. 32 (4): 1001-1015.

Koch, Christian B.; Stenglein, Joseph. 1986. Relationship of specific gravity of yellow-poplar wood to height in tree and growth rate. West Virginia Forestry Notes No. 12. Morgantown, WV: West Virginia University. 11-13.

Koch, Christian B.; Stenglein, Joseph. 1986. Yield and grades by hardwood and softwood rules of lumber sawed from second-growth yellow-poplar logs. Forest Products Journal. 36 (10): 55-59.

Attainment

Productivity can be measured in numerous ways, including return to capital or value added (citation 1). Variation in productivity can be attributed to differences in resource availability, end markets, and capital investment. Such differences must be considered when attempts are made to develop or expand forest products industries in Appalachia or any other region. The selection of the proper tax rate has a substantial effect on investment performance as estimated by the net present value and internal rate of return (citation 2). Selecting an incorrect rate can have a detrimental effect on investment decisions. The possibility of selecting an incorrect rate will exist as long as there are graduated tax schedules. In an analysis of the stumpage market, current lumber prices alone were found to be a poor indicator of timber prices on national forests in West Virginia (citation 3). An analysis of substitutability of poplar lumber for shop grades of softwood lumber indicated that No. 1 Common poplar was the most economical substitute for 4/4 and 5/4 factory select and 5/4 No. 1 and 2 shop grade softwood lumber (Extramural citation 1). This analysis also found that 2A and 2B poplar was the most economical substitute for 4/4 No. 2 and 5/4 No. 3 shop grades, respectively. The market for firewood affects the hardwood sawlog market by providing an outlet for residues that could otherwise be costly to dispose of (Extramural citation 3). An analysis of this market indicates that residential fuelwood demand is quite responsive to changes in the price of nonwood heating fuels.

Northeastern Forest Experiment Station
Forest Inventory and Economic Research
Research Work Unit 4804

ECONOMIC IMPACTS OF WOOD ENERGY, AND ECONOMICS OF MAPLE
SYRUP PRODUCTION

SENDAK, PAUL E., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. ECONOMIC SUPPLY, COST, AND RELIABILITY OF SUPPLY OF WOOD FOR FUEL	RREc	105	1.0	2		3
2. ASSESS SIZE AND MARKET STRUCTURE OF TIMBER USING INDUSTRIES AND WOOD PRODUCTS MANUFACTURED IN NE	RREc	198	1.9			
3. IMPROVING EFFICIENCY OF WATER REMOVAL FROM SUGAR MAPLE SAP.	RREc	10	.1	2		

Problem 1 **ECONOMIC SUPPLY, COST, AND RELIABILITY OF SUPPLY OF
WOOD FOR FUEL**
FY 87 Research Attainments

Publications

Research Unit Dennis, Donald F. 1988. Rates of value change on uncut forest stands in New Hampshire. Northern Journal of Applied Forestry. 4 (2): 64-66.

Dennis, Donald F.; Remington, Susan B. 1987. Trends in harvest cost in New Hampshire: 1964 to 1983. Res. Note NE-335. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 2 p.

Cooperative Donovan, Richard Z.; Huyler, Neil. 1986. Impact of large biomass demand centers on the forest resource base. In: Smith, C. Tattersall; Martin, C. Wayne; Tritton Louise M., eds. Proceedings of the 1986 symposium on the productivity of northern forests following biomass harvesting.; 1986 May 1-2; Durham, NH. NE-GTR-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 17-22.

(Work Unit scientist wrote 50 percent of manuscript and reviewed and edited complete manuscript.)

Huyler, Neil K.; Mishkit, Tim D. 1987. Small-scale fuelwood chipping—is it profitable? Montpelier, VT: State of Vermont, Department of Public Service, Energy Unit. 4 p.

Turner, Terry L.; Bousquet, Daniel W.; Huyler, Neil K. 1987. Productivity and operating cost of two medium-size tractors harvesting northern hardwoods in Vermont. Res. Rep. Burlington, VT: University of Vermont, School of Natural Resources. 23 p.

(Work Unit Scientist contributed ideas and participated in writing study plan, conducted the economic analysis, and reviewed and edited final manuscript; Work Unit technician conducted field data collection.)

Attainment

Assessing the potential contribution of wood energy requires information on the economic availability of a suitable wood supply. Analyzing the effect of changing forest conditions and stumpage price trends for other products as well as fuelwood provides basic information. Real stumpage prices for most major sawlog species in New Hampshire and Vermont either declined or were stable for the 6-year period ending 1987. A notable exception was an increase in prices for red oak stumpage. Real fuelwood prices declined during this period. Rates of value change on uncut forest stands in New Hampshire averaged 15.9 percent annually for the 10 years ending 1983.

Timber harvesting costs which are also important in assessing economic availability were examined for New Hampshire from 1964 to 1983. Real harvesting costs declined at an average annual rate of 1.2 percent for sawtimber and 0.8 percent for pulpwood. Harvest cost data for fuelwood was available only from 1973 to 1983. During this period, real harvesting cost increased at an average annual rate of 3.2 percent. Fuelwood harvesting typically involves lower quality and smaller diameter wood, increasing handling cost per unit volume. Small tractors may provide an economic way to remove small, low quality wood in thinnings and stand improvement work. Low product value and small profit margins for fuelwood necessitate efficient harvest planning to keep skid distance to a minimum and to use favorable grades in the direction of load to keep producing at the highest rate possible. Results have been communicated through publications, meetings, and workshops.

Problem 2**ASSESS SIZE AND MARKET STRUCTURE OF TIMBER USING
INDUSTRIES AND WOOD PRODUCTS MANUFACTURED IN NE
FY 87 Research Attainments**

Publications

none

Attainment

No further progress was made on this problem this year. Earlier attainment reported previous years.

Problem 3 **IMPROVING EFFICIENCY OF WATER REMOVAL FROM SUGAR
MAPLE SAP.**
FY 87 Research Attainments

Publications

Research Unit Sendak, Paul E. 1987. Price up, production down but is sugarmaker better off?. New England Farmer-The Sugarmaker. Jan.: A1-A3.

Sendak, Paul E.; Laing, Frederick M. 1986. The forced-draft wood grate. Maple Syrup Digest. 26 (3): 19-22.

Attainment

Work on this problem has been terminated. Progress was summarized in last year's report.

Northeastern Forest Experiment Station
Forest Recreation and Urban Forestry Research
Research Work Unit 4951

FOREST RECREATION INVESTMENT RESEARCH
ECHELBERGER, HERBERT E., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. DETERMINING COSTS OF PROVIDING FOREST RECREATION OPPORTUNITIES	FRR	76	.7	1		2
2. FACTORS THAT AFFECT THE PERCEIVED QUALITY OF FOREST RECREATION OPPORTUNITIES	FRR	178	1.8	4	2	2
3. UNDERSTANDING THE RELATIONSHIPS BETWEEN COSTS OF PROVISION AND PERCEIVED QUALITY	FRR	51	.5	1		3
51. MISCELLANEOUS	FRR	0	.0	3		1

Problem 1 **DETERMINING COSTS OF PROVIDING FOREST RECREATION
OPPORTUNITIES**
FY 87 Research Attainments

Publications

Research Unit Echelberger, Herbert, E; Wiesel, Jonathan B. 1986. Economic analysis of cross-country ski areas. In: Abstracts from the 1986 symposium on Leisure Research; 1986 October; Anaheim, CA. [Alexandria, VA]: National Recreation and Park Association: Abstract.

Cooperative Heywood, John L.; Ahmed, Hassan F.; Mullins, Gary W.; Echelberger, Herbert E. 1987. Estimating costs for providing publicly supported recreation facilities. In: Abstracts of the proceedings of the 10th anniversary leisure research symposium; 1987 September: New Orleans, LA. [Alexandria, VA]: National Recreation and Parks Association: 45 p. Abstract.

Wiesel, J.B.; Echelberger, H.E.; Shepard, B.; Thomas, K.; Deeg, B.F. 1987. Cross-country ski area operations survey: winter 1985-86. Jackson Hole, WY: National Nordic Consultants. 1-8.

Attainment

A study of costs and efficiency of state parks in Ohio found that day-use facilities tend to be labor intensive while overnight facilities tend to be capital intensive. Substantial savings could be realized by reducing personnel services costs at day-use facilities in more primitive parks. For overnight facilities, reduced personnel services costs and increased revenues would be necessary for improved efficiency. This information was made available to potential users at the 1987 NRPA Research Symposium. It is not known yet to what extent the findings are being applied. In a nationwide study of commercial cross-country ski area operations, categories of expenditures and sources of revenue were summarized along with other data about this young industry. This information enables operators to compare their operating characteristics with industry averages, allows potential investors to make more informed investment decisions and presents a picture of the economic contribution that these enterprises are making to the rural economy of snowbelt states. Two reports were produced from this study—an executive report to the participating operators and a more general report given at the 1986 NRPA Research Symposium. The information is being used extensively by area operators, based on their responses to the succeeding survey.

Problem 2

**FACTORS THAT AFFECT THE PERCEIVED QUALITY OF FOREST
RECREATION OPPORTUNITIES
FY 87 Research Attainments**

Publications

Research Unit

Glass, Ronald J. 1987. Comparing the value of deer to timber and farm outputs: inconsistencies in valuation techniques. In: Deer, forestry, and agriculture: interactions and strategies for management; 1987 June 15-17; Warren, PA. Warren, PA: Allegheny Society of American Foresters: 160-172.

Glass, Ronald J.; Gustke, Nancy. 1987. Visitor expectations, satisfactions, and views toward financial support for selected New Hampshire historic sites. NE-RN-334. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Glass, Ronald J.; Muth, Robert M. 1987. Inadequate payoff evaluation as a deterrent to integrated resource management. In: Transactions of the fifty-second North American wildlife and natural resources conference; 1987 March 22-25; Quebec City, Canada. ISSN 0078-1355. Washington, DC: Wildlife Management Institute: 101-111.

More, T. 1986. Social functions of urban open space. In: Program abstracts: first national symposium on social science in resource management; 1986 May 22; Corvallis, OR: [Corvallis, OR]: National Park Service Cooperative Park Studies Unit; Department of Resource Recreation, Oregon State University: 148 p. Abstract.

Cooperative

Cole, Gerald L.; More, Thomas A. 1987. Satisfaction with facilities and services in Delaware state parks including a comparison of survey techniques. F. & R. E. Pamphlet No. 91. Newark, DE: Department of Food and Resource Economics, University of Delaware. 11 p.

McEwen, D.; More, T. 1986. Recreation quality and the market for tent camping. Journal of Park and Recreation Administration. 4 (2): 83-95.

Extramural

Godbey, G.; Guadagnolo, F. 1987. Development of an evaluation instrument for urban parks using a marketing technique. State College, PA: Pennsylvania State University. 70 p.

(This Penn State Report was funded by the Northeastern Station's Pinchot Consortium. Our participation consisted of funding and in the development of the study plan.)

Yearick, Vincent E. 1987. The influence of physical site attributes and motive fulfillment on camping satisfaction in Pennsylvania state parks. State College, PA: Pennsylvania State University, College of Health, Physical Education and Recreation. 113. M.S. thesis.

(This is a Master's Thesis which was completed in August, 1987. Our participation consisted of discussions with faculty at Penn State University culminating in the development of a study plan and funding of a graduate student to carry out the field work and write up the results.)

Attainment

A survey of midwestern campers indicates that those using private, developed campgrounds prefer private sites over open sites, clean restrooms, and will tolerate facilities like game rooms that contribute to profit potential. Tenters in modern, public facilities share similar preference patterns but do not approve of profit-oriented facilities. Campers at primitive sites are less demanding than the other groups for facilities but harbor an extreme dislike of profit-oriented facilities within the campground. These results, communicated to users through the Journal of Park and Recreation Administration, enable managers to segment the camping market on the basis of preferences. In urban parks, quality may be determined by the social function a park serves. Most communities have a variety of park-like spaces that serve differing needs. Understanding these needs and their relationship to the community's resource base can help planners to more effectively utilize scarce open spaces. This information was presented at the First National Symposium on Social Science in Resource Management. Other studies have examined quality-related issues in New Hampshire historic sites, Pennsylvania state parks, and Delaware coastal and inland state parks. An additional finding of the Delaware study was that the data collection method may influence, to some extent, results of a study. Analysis of data from personal interviews versus a postcard-type questionnaire revealed some significant differences in satisfaction scores for facilities and services. Two papers addressed inadequate and inconsistent valuation techniques used by public providers of wildlife resources. These problems could be resolved if management agencies had a better understanding of the relationship between human satisfactions, societal payoffs, and wildlife populations.

Problem 3

**UNDERSTANDING THE RELATIONSHIPS BETWEEN COSTS OF
PROVISION AND PERCEIVED QUALITY
FY 87 Research Attainments**

Publications**Research Unit**

More, Thomas A.; Echelberger, H. 1987. Social equity in state parks. In: Abstracts of the proceedings of the 10th anniversary leisure research symposium; 1987 September; New Orleans, LA. [Alexandria, VA]: National Recreation and Park Association: 73 p. Abstract.

Cooperative

Allen, P.G.; Stevens, T.H.; Yocker, G.; More, T. 1986. The benefits and costs of urban forest parks. Research Bulletin No. 709. Amherst, MA: Massachusetts Agricultural Experiment Station. College of Food and Natural Resources, University of Massachusetts. 45 p.

Stevens, T.; Allen, P.; More, T. 1986. Benefits, costs, revenues and pricing of public forest day-use recreation areas. Research Bulletin 708. Amherst, MA: Massachusetts Agricultural Experiment Station, College of Food and Natural Resources, University of Massachusetts. 29 p.

Stevens, Thomas; Allen, P. Geoffrey; More, Thomas. 1987. Demand and value of day-use outdoor recreation on public lands near urban areas. Resources and environment: management choices. Amherst, MA: Department of Agriculture and Resource Economics, Cooperative Extension, University of Massachusetts. 3 p.

Attainment

In a study of Vermonter opinions regarding fees at state parks it was found that day-use areas are perceived as a legitimate form of government supported recreation while overnight facilities should be priced to more fully cover the costs of provision. Most Vermonters felt that subsidies were appropriate for special groups such as some disabled, needy, senior, or young citizens. This information was communicated to users at the 1987 NRPA Research Symposium. In another study of the benefits and costs of urban forests and parks it was found that the hedonic or property value method of measuring benefits did not fully account for all the known benefits and that this would contribute to inappropriate decisions. The demand for use of state parks has usually been considered to be relatively inelastic. However, a third study has shown that state parks often serve local users who are knowledgeable about substitute opportunities and who would be responsive to fee increases. Therefore, fee increases at these kinds of areas would probably reduce attendance and result in only small increases in total revenues. Moreover, since costs do not vary much with changes in attendance, they would probably not decrease in proportion to the drop in visitors. This information was communicated to managers through the University of Massachusetts Research and Extension publication system. It is currently being adapted by recreation planners and managers in Massachusetts and should spread to a much wider spectrum of users as the concepts are picked up by other state and federal agencies.

Problem 51

MISCELLANEOUS
FY 87 Research Attainments

Publications

Research Unit

Echelberger, Herbert E. 1986. Camping. In: Swzack, Laura, comp., ed. A literature review: the President's commission on Americans outdoors. Washington, DC: U.S. Government Printing Office; Activities -71.

Glass, Ronald J. 1987. Subsistence as a component of the mixed economic base in a modernizing community. In: Alaska's resources, Alaska's Future: 1987 Arctic science conference proceedings, 38th Alaska science conference; 1987 September 24-26; Anchorage, AK. [Anchorage, AK]: American Association for the Advancement of Science - Arctic Division, and Institute of Social and Economic Research, University of Alaska, Anchorage: 190. Abstract.

More, Thomas A. 1986. The productivity of urban parks. In: Swzack, Laura, comp., ed. A literature review: the President's commission on Americans outdoors. Washington, DC: U.S. Government Printing Office; Urban 45-54.

Cooperative

Muth, Robert M.; Ruppert, David E.; Glass, Ronald J. 1987. Subsistence use of fisheries resources in Alaska: implications for Great Lakes fisheries management. In: Transactions of the American Fisheries Society; 1985 September 3-6; Tustin, MI. 116. Washington, DC: American Fisheries Society: 510-518.

Attainment

Two papers, prepared by Project scientists, were published as part of the Report of the President's Commission on Americans Outdoors. These papers review the pertinent research that has been conducted in the fields of family camping and urban park benefits. These findings were applied by the Commission in the development of their recommendations to the President. In some communities of the U.S., subsistence activities are an important component of social, as well as economic, systems. Scientists at the annual meeting of the American Association for the Advancement of Science - Arctic Division were warned that market, public, and subsistence activities in some communities are so intertwined that analytic attempts to isolate the impacts of one from the other are likely to yield erroneous information. The extent to which this information is being applied, and by whom, is not yet known.

Northeastern Forest Experiment Station
Forest Recreation and Urban Forestry Research
Research Work Unit 4952

STRUCTURE AND FUNCTION OF URBAN FORESTS
ROWNTREE, ROWAN A., Project Leader

FY 87 Research Attainments
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. STRUCTURE AND FUNCTION OF URBAN FOREST SYSTEMS	FRR	250	1.0	3	6	3

Problem 1

STRUCTURE AND FUNCTION OF URBAN FOREST SYSTEMS
FY 87 Research Attainments

Publications

Research Unit

Nilon, Charles H.; VanDruff, Larry W. 1986. Analysis of small mammal community data and applications to management of urban greenspaces. In: Integrating man and nature in the metropolitan environment: Proceedings of a national symposium on urban wildlife; 1986 November 4-7; Chevy Chase, MD. Columbia, MD: National Institute for Urban Wildlife: 53-59.

(Unit funded work of Nilon, an employee of NE-4952 until 8/86.)

Nilon, Charles H.; Rowntree, Rowan A.; Natural Resources Group. 1986. Wildlife management in natural areas of New York City parks. In: Integrating man and nature in the metropolitan environment: Proceedings of a national symposium on urban wildlife; 1986 November 4-7; Chevy Chase, MD. Columbia, MD: National Institute for Urban Wildlife: 239. Poster abstract.

(Nilon, employed by NE-4952 until 8/86, developed wildlife habitat appraisal guides. Unit helped fund the research.)

Rowntree, Rowan A. 1986. Ecological values of the urban forest. In: Proceedings of the 3rd National Urban Forestry Conference; 1986 December 7-11; Orlando, FL. Washington, DC: American Forestry Association: 22-24.

Cooperative

McPherson, E. Gregory; Nilon, Charles. 1987. A habitat suitability index model for gray squirrel in an urban cemetery. *Landscape Journal*. 6 (1): 21-30.

(Unit funded work. Nilon, employed by NE-4952 until his departure in 8/86, gathered and analyzed data and co-authored manuscript.)

McPherson, E. Gregory; Rowntree, Rowan A. 1986. Ecological measures of structure and change for street tree populations. In: Proceedings of 3rd National Urban Forestry Conference; 1986 December 7-11; Orlando, FL. Washington, DC: American Forestry Association: 65-76.

(Rowan conceived study, revised manuscript. McPherson gathered and analyzed data, wrote first draft.)

Sadowski, Frank G.; Sturdevant, James A.; Rowntree, Rowan A. 1987. Testing the consistency for mapping urban vegetation with high-altitude aerial photographs and Landsat MSS data. *Remote Sensing of Environment*. 21: 129-141.

(Rowntree conceived study, supervised data gathering, revised draft. Sadowski conducted Landsat analyses and wrote first draft. Sturdevant assisted Sadowski.)

Extramural

Connelly, Nancy A.; Brown, Tommy L.; Allee, David J. 1986. Assessing the economic impact of state parks located near urban areas in New York and the effect of these impacts on the budget allocation process. Series No. 86-6. Ithaca, NY: Dept. of Natural Resources, Cornell University. 62 p.

(Funded by the Consortium for Environmental Forestry Studies. Rowntree reviewed study plan and final report.)

McPherson, E. Gregory. 1987. Effects of vegetation on building energy performance. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 245 p. Ph.D. dissertation.

(Unit funded the student's work. Rowntree served on the thesis committee.)

Pizor, Peter J. 1985. Transfer of development rights: two case histories. Plainfield, NJ: New Jersey Federation of Planning Officials; Federation Planning Information Report, Federation Planning Information. 18(4): 15.

(Funded by the Consortium for Environmental Forestry Studies. Rowntree reviewed study plan and final report.)

Pizor, Peter J. 1986. Making TDR work. *Journal of the American Planning Association*. 52 (2): 203-212.

(Funded by the Consortium for Environmental Forestry Studies. Rowntree reviewed study plan and final report.)

Talarchek, Gary M. 1987. Indicators of urban forest condition in New Orleans. *Journal of Arboriculture*. 13 (9): 217-224.

(Unit funded research, Rowntree helped develop research plan.)

Zipperer, Wayne C. 1987. Vegetation and landscape analysis of woodlots in central New York. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 349 p. Ph.D. dissertation.

(Work was funded by a cooperative agreement from NE-4952 and a grant from the Consortium for Environmental Forestry Studies.)

Attainment

Progress on understanding urban forest "structure" was made by evaluating two different types of remote sensing for mapping urban vegetation: high-altitude color infrared air photography and the Landsat satellite's Multispectral Scanner. The work evaluated the conditions under which each remote sensing instrument would be most appropriate. It is the first time either instrument has been evaluated for urban vegetation mapping. Ecological measures traditionally used in non-urban forest structural analyses were evaluated, and modified, for application to urban forests. These measures allow for comparing such attributes as species diversity, dominance, and age class distribution among a number of urban forests and, also, for plotting trends in species composition over time. Progress on understanding the way urban forests affect the environment - "function" - was made in the following areas: computer simulation of trees interfering with sun and wind, affecting the heating and cooling costs of a residence, the application of wildlife habitat modeling for small mammals to urban forest situations, and the application of small mammal community data to the management of urban greenspaces. Progress was also made in understanding, and managing, land conversion processes in the urban-wildland interface (UWI) zone in a study which tested the ability of a legal mechanism called "transfer of development rights" to preserve natural forest land on the fringe of a growing urban area. A related study examined how important these natural areas are to the urban economic base. In another study, changes over a 60-year period in the vegetational pattern of woodlots in Central New York (within the UWI zone) were analyzed. Most of the progress to date has been relayed to users through published articles and presentations at national conferences.

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- Brooks, Robert T. 1986. Forest land wildlife habitat resources of South-Central Ohio. *Resour. Bull. NE-94*. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 31 p.
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- Gansner, David A.; Herrick, Owen W. 1987. Estimating the benefits of gypsy moth control on timberland. *Res. Note. NE-337*. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.
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Wharton, Eric H.; Nevel, Robert L., Jr.; Powell, Douglas S. 1987. Supply and demand of timber for wood turning in Maine. Res. Pap. NE-599. Broomall: PA. 29 p.

Widmann, Richard H. 1987. Pulpwood production in the Northeast-1985. Resour. Bull. NE-99. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.

Widmann, Richard H.; Long, Michael. 1986. Ohio timber products output-1983. Resour. Bull. NE-95. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

**Forest Insect and
Disease Research**

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